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THE PROGRESS OF SCIENCE.*

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A CONSTITUTIONAL provision of our Association stipulates that "It shall be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided." Happily for those of us who must in turn fulfill this duty the scientific foresight of our predecessors set no metes and bounds with respect to the subject-matter or the mode of treatment of the theme that might be chosen for such an address. So far, therefore, as constitutional requirements are concerned, a retiring president finds himself clothed for the time being with a degree of liberty which might be regarded as dangerous were it not for an unwritten rule that one may not hope to enjoy such liberty more than once. But time and place, nevertheless, as well as the painful personal limitations of any specialist, impose some rather formidable restrictions. One may not tax lightly, even, in a summer evening, the patience of his audience for more than an academic hour, the length of which in most cases is less than sixty minutes. One must confine himself to generalities, which, though scientifically hazardous, serve as a basis for semi-popular thought; and one must exclude technical details, which, though scientifically essential, tend only to obscure semi-popular presentation. Courtesy, also, to those who are at once our hosts and our guests requires that, so far as possible, one should substitute the vernacular for the 'jargon of science,' and draw his figures of speech chiefly from the

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broad domain of every-day life rather than from the special, though rapidly widening, fields of scientific activity.

Between this nominally unlimited freedom on the one hand, and these actually narrow restrictions on the other, I have chosen to invite your attention for the hour to a summary view of the salient features of scientific progress, with special reference to its effects on the masses, rather than on the individuals, of mankind. We all know, at least in a general way, what such progress is. We are assured almost daily by the public press and by popular consent that the present is not only an age of scientific progress, but that it is preeminently the age of scientific progress. And with respect to the future of scientific achievement, the consensus of expert opinion is cheerfully hopeful, and the consensus of public opinion is extremely optimistic. Indeed, to borrow the language sometimes used by the rulers of nations, it may be said that the realm of science is now at peace with all foreign parts of the world, and in a state of the happiest domestic prosperity.

But times have not been always thus pleasant and promising for science. As we look backward over the history of scientific progress it is seen that our realm has been taxed often to the utmost in defense of its autonomy, and that the present state of domestic felicity, bordering on tranquillity, has been preceded often by states of domestic discord bordering on dissolution. And, as we look forward into the new century before us, we may well enquire whether science has vanquished its foreign enemies and settled its domestic disputes for good and all, or whether future conquests can be made only by a similarly wasteful outlay of energy to that which has accompanied the advances of the past. Especially may we fitly enquire on an occasion like the present what are the types of mind and the methods of procedure which make for the progress, and what are the types of mind and the methods of procedure which make for the regress, of science. And I venture to think that we may enquire also with profit, in some prominent instances, under what circumstances in the past science has waxed or waned, as the case may be, in its slow rise from the myths and mysticism of earlier eras to the law and order of the present day. For it is a maxim of common parlance, too well justified, alas! by experience, that history repeats itself; or, to state the fact less gently, that the blunders and errors of one age are repeated with little variation in the succeeding age. This maxim is strikingly illustrated by the history of science, and it has been especially deeply impressed upon us—burnt in, one might say—by the scientific events of our own times. Have we not learned, however, some lasting lessons in the hard school of experience, and may we not transmit to our successors along with the established facts and principles of science the almost equally well established ways and means for the

advancement of science? Will it be possible for society to repeat in the twentieth century the appalling intellectual blunders of the nineteenth century, or have we entered on a new era in which, whatever other obstacles are pending, we may expect man to stand notably less in his own light as regards science than ever before? To a consideration of these and allied questions I beg your indulgence, even though I may pass over ground well known to most of you, and encroach, perhaps, here and there, on prominences in fields controversial; for it is only by discussion and rediscussion of such questions that we come at last, even among ourselves in scientific societies, to the unity of opinion and the unity of purpose which lead from ideas to their fruitful applications.

From the earliest historic times certainly, if not from the dawn of primitive humanity, down to the present day, the problem of the universe has been the most attractive and the most illusive subject of the attention of thinking men. All systems of philosophy, religion and science are alike in having the solution of this problem for their ultimate object. Many such systems and sub-systems have arisen, flourished and vanished, only to be succeeded by others in the seemingly Sisyphean task. Gradually, however, in the lapse of ages there have accumulated some elements of knowledge which give inklings of partial solutions; though it would appear that the best current opinion of philosophy, religion and science would again agree in the conclusion that we are yet immeasurably distant from a complete solution. Almost equally attractive and interesting, and far more instructive, as it appears to me, in our own time, is the contemplation of the ways in which man has attacked this perennial riddle. It is, indeed, coming to be more and more important for science to know how primitive, barbarous and civilized man has visualized the conditions of, and reached his conclusions with respect to, this problem of the centuries; for it is only by means of a lively knowledge of the baseless hypotheses and the fruitless methods of our predecessors that we can hope to prevent history from repeating itself unfavorably.

Looking back over the interval of two to three thousand years that connects us by more or less authentic records with our distinguished ancestors, we are at once struck by the admirable confidence they had acquired in their ability to solve this grand problem. Not less admirable, also, for their ingenuity and for the earnestness with which they were advanced, are the hypotheses and arguments by which men satisfied themselves of the security of their tenets and theories. Roughly speaking, it would appear that the science of the universe received its initial impulse from earliest man in the hypothesis that the world is composed of two parts; the first and most important part being in fact,

if not always so held ostensibly, himself, and the other part being the aggregate of whatever else was left over. Though dimly perceived and of little account in its effects, this is, apparently, the working hypothesis of many men in the civilized society of to-day. But the magnitude of the latter part and its inexorable relations to man seem to have led him speedily to the adoption of the second hypothesis, namely, that the latter part, or world external to himself, is also the abode of sentient beings, some of a lower and some of a higher order than man; their rôle tending on the whole to make his sojourn on this planet tolerable and his exit from it creditable, while yet wielding at times a more or less despotic influence over him.

How the details of these hypotheses have been worked out is a matter of something like history for a few nationalities, and is a matter absorbing the attention of anthropologists, archeologists and ethnologists as it concerns races in general. Without going far afield in these profoundly interesting and instructive details, it may suffice for the present purposes to cite two facts which seem to furnish the key to a substantially correct interpretation of subsequent developments.

The first of these is that the early dualistic and antithetical visualization of the problem in question has persisted with wonderful tenacity down to the present day. The accessible and familiar was set over against the inaccessible and unfamiliar; or what we now call the natural, though intimately related to, was more or less opposed to the supernatural; the latter being, in fact, under the uncertain sway of, and the former subject to the arbitrary jurisdiction of, good and evil spirits.

The second fact is that man thus early devised for the investigation of this problem three distinct methods, which have likewise persisted with equal tenacity, though with varying fortunes, down to the present day. The first of these is what is known as the à priori method. It reasons from subjective postulates to objective results. It requires, in its purity, neither observation nor experiment on the external world. It often goes so far, indeed, as to adopt conclusions and leave the assignment of the reasons for them to a subsequent study. The second is known as the historico-critical method. It depends, in its purity, on tradition, history, direct human testimony and verbal congruity. It does not require an appeal to Nature except as manifested in man. It limits observation and experiment to human affairs. The third is the method of science. It begins, in its elements, with observation and experiment. Its early applications were limited mostly to material things. In its subsequent expansion it has gained a footing in nearly every field of thought. Its prime characteristic is the insistence on objective verification of its results.

All these methods have been used more or less by all thinking men. But for the purpose of ready classification it may be said that the first has been used chiefly by dogmatists, including especially the founders and advocates of all fixed creeds from the atheistic and the pantheistic to the theistic and the humanistic; the second has been used chiefly by humanists, including historians, publicists, jurists and men of letters; and the third has been used chiefly by scientists, including astronomers, mathematicians, physicists, naturalists, and more recently the group of investigators falling under the comprehensive head of anthropologists. The first and third methods are frequently found to be mutually antithetical, if not mutually exclusive. The second occupies middle ground. Together they are here set down in the order of their apparent early development and in the order of their popularly esteemed importance during all historic time previous to, if not including, this first year of the twentieth century.

No summary view of the progress of science, it seems to me, can be made intelligible except by a clear realization of these two facts, which may be briefly referred to as man's conception of the universe and his means of investigating it. What, then, in the light of these facts, has been the sequel? The full answer to this question is an old and a long story, now a matter of minute and exhaustive history as regards the past twenty centuries. I have no desire to recall the dramatic events involved in the rise of science from the Alexandrian epoch to the present day. All these events are trite enough to men of science. A mere reference to them is a sufficient suggestion of the existence of a family skeleton. But, setting aside the human element as much as possible, it may not be out of place or time to state what general conclusions appear to stand out plainly in that sequel. These are our tangible heritage and upon them we should fix our attention.

In the first place, the progress of science has been steadily opposed to, and as steadily opposed by, the adherents of man's primitive concepts of the universe. The domain of the natural has constantly widened and the domain of the supernatural has constantly narrowed. So far, at any rate, as evil spirits are concerned, they have been completely cast out from the realm of science. The arch fiend and the lesser princes of darkness are no longer useful even as an hypothesis. We have reached—if I may again use the cautious language of diplomacy—a satisfactory modus vivendi if we have not attained permanent peace in all our foreign relations. Enlightened man has come to see that his highest duty is to cooperate with Nature, that he may expect to get on very well if he heeds her advice, and that he may expect to fare very ill if he disregards it.

Secondly, it appears to have been demonstrated that neither the à

priori method of the dogmatists nor the historico-critical method of the humanists is alone adequate for the attainment of definite knowledge of either the internal or the external world, or of their relations to one another. In fact, it has been shown over and over again that man cannot trust his unaided senses even in the investigation of the simplest and most obvious material phenomena. There is an ever-present need of a correction for personal equation. Left to himself, the à priori reasoner weaves from the tangled skein of thought webs so well tied with logical knots that there is no escape for the imprisoned mind except by resort to the weapon applied to cobwebs. And in the serenity of his repose behind the fortress of 'liberal culture,' the reactionary humanist will prepare apologies for errors and patch up compromises between traditional beliefs and sound learning with such consummate literary skill that even 'the good demon of doubt' is almost persuaded that if knowledge did not come to an end long ago it will soon reach its limit. In short, we have learned, or ought to have learned, from ample experience, that in the search for definite, verifiable knowledge we should beware of the investigator whose equipment consists of a bundle of traditions and dogmas along with formal logic and a facile pen; for we may be sure that he will be more deeply concerned with the question of the safety than with the question of the soundness of scientific doctrines.

Thirdly, it has been demonstrated equally clearly, and far more cogently, that the sort of knowledge we call scientific, knowledge which has in it the characteristics of immanence and permanence, is founded on observation and experiment. The rise and growth of every science illustrate this fact. Even pure mathematics, commonly held to be the à priori science par excellence, and sometimes called 'the science of necessary conclusions,' is no exception to the rule. Those who would found mathematics on a higher plane have apparently forgotten to consider the contents of the mathematician's waste-basket. The slow and painful steps by which astronomy has grown out of astrology and chemistry out of alchemy; and the faltering, tedious, and generally hotly contested, advances of geology and biology have been made secure only by the remorseless disregard which observational and experimental evidence has shown for the foregone conclusions of the dogmatists and the literary opinions of the humanists. Thus it has been proved by the rough logic of facts and events that the rude processes of 'trial and error,' processes which many philosophers and some men of science still affect to despise, are the most effective means yet devised by man for the discovery of truth and for the eradication of error.

These facts are so well known to most of you, so much a matter of ingrained experience, that the categorical mention of them here may

seem like a rehearsal of truisms. But it is one of the paradoxes of human development that errors which have been completely dislodged from the minds of the few may still linger persistently in the minds of the many, and that the misleading hypotheses and the dead theories of one age may be resuscitated again and again in succeeding ages. Thus, to cite one of the simplest examples, it doubtless appeared clear to the Alexandrian school of scientists that the flat, four-cornered earth of contemporary myths would speedily give way to the revelations of geometry and astronomy. How inadequate such revelations proved to be at that time is one of the most startling disclosures in all history. The 'Divine School of Alexandria' passed into oblivion. The myth of a flat and four-cornered earth was crystallized into a dogma strong enough to bear the burden of men's souls by Cosmas Indicopleustes in the sixth century; it was supported with still more invincible arguments by Martin Luther in the sixteenth century; and it was revived and maintained with not less truly admirable logic, as such, by John Hampden and John Jasper in the last decades of the nineteenth century. To cite examples from contemporary history showing how difficult it is for the human mind to get above its primitive conceptions, one needs only to refer to the daily press. During the past two months, in fact, the newspapers have related how multitudes of men, women and children, many of them suffering from loathsome if not contagious diseases, have visited a veritable middle age shrine in the city of New York, strong in the hoary superstition that kissing an alleged relic of St. Anne would remove their afflictions. During the same interval a railway circular has been distributed explaining how tourists may witness the Moki snake-dance, that weird ceremony by which the Pueblo Indian seeks to secure rain in his desert; and a similar public, and officially approved, ceremony has been observed in the heat-stricken State of Missouri.

Such epochs and episodes of regression as these must be taken into account in making up an estimate of scientific progress. They show us that the slow movement upward in the evolution of man which gives an algebraic sum of a few steps forward per century is not inconsistent with many steps backward. Or, to state the case in another way, the rate of scientific advance is to be measured not so much by the positions gained and held by individuals, as by the positions attained and realized by the masses, of our race. The average position of civilized man now is probably below the mean of the positions attained by the naturalist Huxley and the statesman Gladstone, or below the mean of the positions attained by the physicist von Helmholtz and His Holiness the Pope. When measured in this manner, the rate of progress in the past twenty centuries is not altogether flattering or encouraging to us,

especially in view of the possibility that some of the more recently developed sciences may suffer relapses similar to those which so long eclipsed geography and astronomy.

It must be confessed, therefore, when we look backward over the events of the past two thousand years, and when we consider the scientific contents of the mind of the average denizen of this planet, that it is not wholly rational to entertain millennial anticipations of progress in the immediate future. The fact that some of the prime discoveries of science have so recently appeared to many earnest thinkers to threaten the very foundations of society is one which should not be overlooked in these confident times of prosperity. And the equally important fact that entire innocence with respect to the elements of science and dense ignorance with respect to its methods, have not been hitherto incompatible with justly esteemed eminence in the divine, the statesman, the jurist and the man of letters, is one which should be reckoned with in making up any forecast. It may be seriously doubted, indeed, whether the progress of the individual is not essentially limited by the progress of the race.

But this obverse and darker side of the picture which confronts us from the past has its reverse and brighter side; and I am constrained to believe that the present status of science and the general enlightenment of humanity justify ardent hopefulness if not sanguine optimism with respect to the future of scientific achievement. The reasons for this hopefulness are numerous; some of them arising out of the commercial and political conditions of the world, and others arising out of the conditions of science itself.

Perhaps the most important of all these reasons is found in the general enlargement of ideas which has come, and is coming, with the extension of trade and commerce to the uttermost parts of the earth. We are no longer citizens of this or that country, simply. Whether we wish it or not we are citizens of the world, with increased opportunities and with increased duties. We may not approve—few men of science would approve, I think—that sort of 'expansion' which works 'benevolent assimilation' of inferior races by means of a bible in one hand and a gun in the other; but nothing can help so much, it seems to me, to remove the stumbling blocks in the way of the progress of science as actual contact with the manners, the customs, the relations and the resulting questions for thought, now thrust upon all civilized nations by the events of the day. That sort of competition which is the life of trade, that sort of rivalry which is the stimulus to national effort, and that sort of cooperation which is essential for mutual protection, all make for the cosmopolitan dissemination of scientific truth and for the appreciation of scientific investigation. I would not dis-

parage the elevated aspirations and the noble efforts of the evangelists and the humanists who seek to raise the lower to the plane of the higher elements of our race; but it is now plain as a matter of fact, however repulsive it may seem to some of our inherited opinions, that the railway, the steamship, the telegraph and the daily press will do more to illumine the dark places of the earth than all the apostles of creeds and all the messengers of the gospel of 'sweetness and light.'

A question of profound significance growing out of the extension of commercial relations in our time is what may be called the question of international health. An outbreak of cholera in Hamburg, the prevalence of yellow fever in Havana or an epidemic of bubonic plague in India is no longer a matter of local import, as nations with which we are well acquainted have learned recently in an expensive manner. The management of this great international question calls for the application of the most advanced scientific knowledge and for the most intricate scientific investigation. Large sums of money must be devoted to this work, and many heroic lives will be lost, doubtless, in its execution; but it is now evident, as a mere matter of international political economy, that the cost of sound sanitation will be trifling in comparison with the cost of no sanitation; while further careful study of the natural history of diseases promises practical immunity from many of them at no distant day. International associations of all kinds must aid greatly also in the promotion of progress. Many such organizations have, indeed, already undertaken scientific projects with the highest success. Comparison and criticism of methods and results not only lead rapidly and effectively to improvements and advances, but they lead also to a whole-hearted recognition of good work which puts the fraternalism of men of science on a plane far above the level of the amenities of merely diplomatic life.

When we turn to the general status of science itself, there is seen to be equal justification for hopefulness founded on an abundance of favorable conditions. The methods of science may be said to have gained a footing of respectability in almost every department of thought, where, a half-century ago, or even twenty years ago, their entry was either barred out or stoutly opposed. The 'Conflict between Religion and Science'—more precisely called the conflict between theology and science—which disturbed so many eminent though timid minds, including not a few men of science a quarter of a century ago, has now been transferred almost wholly to the field of the theological contestants; and science may safely leave them to determine the issue, since it is evidently coming by means of scientific methods. The grave fears entertained a few decades ago by distinguished theologians and publicists as to the stability of the social fabric under the stress put upon it by the rising tide of scientific ideas, have not been realized.

And, on the other hand, the grave doubts entertained by the distinguished men of science a few decades ago as to the permeability and ready response of modern society to that influx of new ideas, have likewise not been realized. It is true that we still sometimes read of theological tests being applied to teachers of biology, and hear, occasionally, of an earnest search for a good methodist or a good presbyterian mathematician; but such cases may be left for settlement out of court by means of the arbitration of our sense of humor. It seems not unlikely, also, that there may persist, for a long time to come, a more or less guerrilla 'warfare of science' with our friends the dogmatists and humanists. Some consider this conflict to be, in the nature of things, irrepressible. But I think we may hope, if we may not confidently expect, that the collisions of the future will occur more manifestly than they have in the past in accordance with the law of the conservation of energy; so that the heat evolved may reappear as potential energy in the warmth of a kindly reasonableness on both sides, rather than suffer degradation to the level of cosmic frigidity.

Great questions, also, of education, of economic, industrial and social conditions, and of legal and political relations are now demanding all the light which science can bring to bear upon them. Though tardily perceived, it is now admitted, generally, that science must not only participate in the development of these questions, but that it alone can point the way to the solutions of many of them. But there is no halting ground here. Science must likewise enter and explore the domain of manners and morals; and these, though already largely modified unconsciously, must now be modified consciously to a still greater extent by the advance of science. Only within quite recent times have we come to realize an approximation to the real meaning of the trite saying that the proper study of man is man. So long as the most favored individuals of his race, in accordance with the hypothesis of the first centuries, looked upon him as a fallen, if not a doomed, resident of an abandoned reservation, there could be roused little enthusiasm with respect to his present condition; all thought was concentrated on his future prospects. How incomparably different does he appear to the anthropologist and the psychologist at the beginning of the twentieth century! In the light of evolution he is seen to be a part of, and not apart from, the rest of the universe. The transcendent interest of this later view of man lies in the fact that he can not only investigate the other parts of the universe, but that he can, by means of the same methods, investigate himself.

I would be the last to look upon science as furnishing a speedy or a complete panacea for the sins and sorrows of mankind; the destiny of our race is entangled in a cosmic process whose working is thus far only dimly outlined to us; but it is nevertheless clear that there are

available to us immense opportunities for the betterment of man's estate. For example, to mention only one of the lines along which improvement is plainly practicable, what is to hinder an indefinite mitigation, if not a definite extinction, of the ravages of such dread diseases as consumption and typhoid fever? Or what, we may ask, is to hinder the application to New York, Philadelphia and Chicago of as effective health regulations as those now applied to Havana? Nothing, apparently, except vested interests and general apathy. We read, not many years ago, that a city of about one million inhabitants had, during one year, more than six thousand cases of typhoid fever. The cost to the city of a single case may be estimated as not less, on the average, than one thousand dollars, making an aggregate cost to that city, for one year, of more than six millions of dollars. Such a waste of financial resources ought to appeal to vested interests and general apathy even though they cannot be moved by any higher motives. Thanks to the penetration of the enlightenment of our times, distinct advances have already been made in the line of effective domestic and public sanitation; but the good work accomplished is infinitesimal in comparison with that which can be, and ought to be, done. It is along this and along allied lines of social and industrial economy, that we should look, I think, for the alleviation of the miseries of mankind. No amount of contemplation of the beatitudes, human or divine, will prevent men from drinking contaminated water or milk; and no fear of future punishments, which may be in the meantime atoned for, will much deter men from wasting their substance in riotous living. The moral certainty of speedy and inexorable earthly annihilation is alone adequate to bring man into conformity with the cosmic rules and regulations of the drama of life.

And finally we must reckon amongst the most important of the conditions favorable to the progress of science, the unexampled activity in our times of the scientific spirit as manifested in the work of all kinds of organizations, from the semi-religious Chautauquan assemblies up to those technical societies whose programs are Greek to all the world beside. Literature, linguistics, history, economics, law and theology are now permeated by the scientific spirit if not animated by the scientific method. Curiously enough, also, the terminology, the figures of speech and the points of view of science are now quite common in realms of thought hitherto held somewhat scornfully above the plane of materialistic phenomena. Tyndall's Belfast address, which, twenty-seven years ago, was generally anathematized, is now quoted with approval by some of the successors of those who bitterly denounced him and all his kind. Thus the mere lapse of time is working great changes and smoothing out grave differences of opinion in favor of the progress

of science in all the neighboring provinces with which we have been able hitherto to maintain only rather strained diplomatic relations.

Still more immediately important to us are the evidences of progress manifested in recent years by this Association and by its affiliated societies. Our parent organization, though a half century old, is still young as regards the extent in time of the functions it has undertaken to perform. It has accomplished a great work; but in the vigor and enthusiasm of its youth a far greater work is easily attainable. Exactly how these functions are to be developed, no man can foresee. We may learn, however, in this, as in other lines of research, by methods with which we are well acquainted, namely, by the methods of carefully planned and patiently executed observation and experiment. The field for energetic and painstaking effort is wider and more attractive than ever before. Science is now truly cosmopolitan; it can be limited by no close corporations; and no domain of scientific investigation can be advantageously fenced off, either in time or in space, from the rest. While every active worker of this or of any affiliated society is, in a sense, a specialist, there are occasions when he should unite with his colleagues for the promotion of the interests of science as a whole. The results of the specialists need to be popularized and to be disseminated among the people at large. The advance of knowledge, to be effective with the masses of our race, must be sustained on its merits by a popular verdict. To bring the diverse scientific activities of the American Continent into harmony for common needs; to secure cooperation for common purposes; and to disseminate the results of scientific investigation among our fellow-men, are not less, but rather much more, than in the past, the privilege and the duty of The American Association for the Advancement of Science.

Viewed, then, in its broader aspects, the progress of science is involved in the general progress of our race; and those who are interested in promoting the former should be equally earnest in securing the latter. However much we may be absorbed in the details of our specialties, when we stop to think of science in its entirety, we are led, in the last analysis, back to the problem of problems—the meaning of the universe. All men 'gifted with the sad endowment of a contemplative mind' must recur again and again to this riddle of the centuries. We are, so to speak, whatever our prepossessions, all sailing in the same boat on an unknown sea for a destination at best not fully determined. Some there are who have, or think they have, the Pole Star always in sight. Others, though less confident of their bearings, are willing to assume nothing short of second place in the conduct of the ship. Others, still less confident of their bearings, are disposed to depend chiefly on their knowledge of the compass and on their skill in dead reckoning. We of the last class may not impugn the motives or doubt the sincerity

of the first two classes. We should find it difficult, probably, to dispense with their company in so long a journey after becoming so well acquainted with them; for among them we may each recall not a few of those rarer individuals of the genus homo called angels on earth. But it must be said in all truth, to resume the figure, that they have neither improved much the means of transportation nor perfected much the art of navigation. They have been sufficiently occupied, perhaps, in allaying the fears of the timid and in restraining the follies of the mutinous. Other types of mind and other modes of thought than theirs have been essential to work out the improvements which separate the earlier from the later nautical equipments of men; such improvements, for example, as mark the distinction between the dug-out of our lately acknowledged relatives, the Moros and the Tagalogs, and the Atlantic-liner of to-day.

At any rate, we are confronted by the fact that man's conceptions of the universe have undergone slow but certain enlargement. His early anthropocentric and anthropomorphic views have been replaced, in so far as he has attained measurable advancement, by views that will bear the tests of astronomy and anthropology. He has learned, slowly and painfully, after repeated failures and many steps backward, to distinguish, in some regions of thought, the real and the permanent from the fanciful and fleeting phenomena of which he forms a part. His pursuit of knowledge, in so far as it has led him to certainty, has been chiefly a discipline of disillusionment. He has arrived at the truth not so much by the genius of direct discovery as by the laborious process of the elimination of error. Hence he who has learned wisdom from experience must look out on the problem of the universe at the beginning of the twentieth century with far less confidence in his ability to speedily solve it and with far less exaggerated notions of his own importance in the grand aggregate of Nature, than man entertained at the beginning of our era. But no devotee to science finds humiliation in this departure from the primitive concepts of humanity. On the contrary, he has learned that this apparent humiliation is the real source of enlightenment and encouragement; for notwithstanding the relative minuteness of the speck of cosmic dust on which we reside, and notwithstanding the relative incompetency of the mind to discover our exact relations to the rest of the universe, it has yet been possible to measure that minuteness and to determine that incompetency. These, in brief, are the elements of positive knowledge at which we have arrived through the long course of unconscious, or only half-conscious, experience of mankind. All lines of investigation converge toward or diverge from these elements. It is along such lines that progress has been attained in the past, and it is along the same lines that we may expect progress to proceed in the future.

'FREE-WILL' AND THE CREDIT FOR GOOD ACTIONS.

By Professor GEORGE STUART FULLERTON,
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WE can imagine what would be the emotion of a college professor if the president of the institution were to shake him warmly by the hand and congratulate him upon the fact that, although he had been freely admitted for a year to the book-stack of the college library, he had not stolen so much as a single volume. We can conceive the embarrassment of a clergyman whose bishop would feel impelled to give expression to his satisfaction at the fact that, during a visit extending over a week or more, he had not been distressed by hearing any word of profanity or observing any act of violence. 'What in the world can the man have been expecting of me?' exclaims the indignant recipient of such a compliment. 'Does he take me for a blackleg? Perhaps the next time he sees me he will take it upon himself to felicitate me on having so far escaped the gallows.'

The fact is that whenever we speak of a man as deserving credit for this or that worthy action, our compliment is accompanied by something very like a criticism. It is implied that the action is one not easy to perform, at least in the given instance. We do not ordinarily think a mother deserves great credit for taking good care of her infant, or a father for supporting his family when he has it in his power to do so. We assume that these things are easy and natural, and quite in accord with the impulses which control the individual. But we do think a woman deserves credit for adopting and lavishing her care upon motherless children that have no special claim upon her, and a man for laboring to feed those who are not bound to him by the closest of natural ties. Were it as easy to care for the children of others as to care for one's own, were the impulse to do so just as strong, we should never think of such actions as especially creditable. They would undoubtedly be good actions, but it is one thing to recognize actions as good and quite another to single them out as deserving of credit. It is a good thing for a college professor not to steal, and for a clergyman to avoid acts of violence, but we never think of remarking upon the fact that their conduct is creditable, when we have nothing better to say of them than that they possess these negative virtues.

Some virtues we expect of men generally. We assume that the right course is the easy one to take, or, at least, is relatively easy, and we

scarcely think of praising the average man for coming up to this standard. Some virtues we expect of certain classes of men, and not in the same degree of others. We expect, for example, a greater foresight and power of self-control in those who have enjoyed educational advantages and whose horizon has been widened. And we expect a much greater sensitiveness to moral considerations on the part of those who have had the inestimable advantage of good moral training, and have been brought up in a good home. We judge a man according to the class in which we find him; if he falls below the expected standard of excellence, we blame him, and if he rises above it, we regard him as worthy of credit. But besides these class-standards, which may be very numerous, we have individual standards which we apply when we come to know individual men well, and these express our judgment of the actual moral condition of the individual.

We have, perhaps, known our friend Smith for ten years or more, and have clearly perceived that he readily falls a prey to irascible impulses. He himself deplores the fact, and resolves to express himself more temperately when things happen to ruffle him. We see him on some trying occasion with flushed cheek and the flash in his eye that has heretofore heralded the tempest. But the expected storm does not come; the good resolution has triumphed, and the clouds roll away without emptying themselves as the weather-wise had fully expected them to do. Of course we give Smith no little credit for this victory, and if we really know him intimately we probably endeavor to let him know, in some tactful way, that we admire his magnanimity and self-control. Or perhaps the individual to whom we give credit for a rather unexpected act of self-denial is our son Tommy, whom we have known rather intimately for a number of years, and with whose impulses and capabilities we think we are fairly well acquainted. The boy has on various occasions found stolen jam irresistibly sweet, and neither reflections upon the possibilities of detection and punishment nor the feeble stings of an immature conscience have sufficed to deter him from tasting that sweetness. But we discover that, on a certain occasion, opportunity has not been lacking. There has been a prolonged conflict between the law in his members and the law in his mind, and the latter has come off victorious. We praise Tommy for his continence, make him feel that he has left the field covered with glory, and we devise means of implanting in his small mind the conviction that honesty is not a thing to be regretted.

In this last instance we have, I think, a good indication of what we really mean by the credit that is given to this or that good action, and of the standard by which we measure it. We think of an action as creditable when we recognize the presence of warring impulses, and regard the good decision as a victory over a more or less redoubtable enemy. The

more evenly balanced the force in the field, the more creditable we consider a choice of the right. When we feel personally responsible for the conduct of the individual concerned, we recognize the degree of credit he has earned as a moral claim upon us for payment in coin of some sort. The payment may consist in expressions of approval, in evidences of confidence or of affection, in marks of respect; or it may consist in a large portion of jam at the next distribution, a visit to the circus or a trip to the country. This payment, which parents and teachers do not fail to make if they properly realize their responsibilities, is not made because the child *is good,* for good actions performed easily and without a struggle are not singled out for reward in this way. It is made because the child *needs to be made good,* and we roughly proportion the reward to the amount of encouragement needed to keep the child moving along the path of moral development.

In the larger world beyond the nursery and the school, rewards for creditable behavior are not always distributed in the same unmistakable way. A good deal of creditable behavior appears to be unrewarded. The reason is not far to seek. Men generally are not occupied in educating each other just as parents and teachers educate those under their charge. They have not the same sense of responsibility; and, further, they have not, in many cases, the power to grant rewards. But it is easy to see that, where men are at all sensitive, as civilized human beings surely ought to be, to the moral or immoral character of the actions of their fellows, they are quick to judge of actions as creditable or discreditable, and they have the disposition to mete out to the doer some sort of reward or some sort of penalty. The reward may be no more than a look of admiration or a word of appreciation, and the penalty no more than a slight coldness of manner; but love of approbation is a strong motive to action, and just such rewards and penalties as these may have an enormous influence in determining to right conduct. And where certain men exercise over others a control at all analogous to that exercised by the parent or teacher, we find that they are very apt to reward creditable behavior much as these do. The unusual devotion of this or that employee, the conspicuous bravery of the soldier, are not commonly passed over as matters that deserve no substantial recognition. The good behavior of the convict is accounted as sufficient reason for shortening the term of his imprisonment. Look where we will, we find that there is a general tendency among men to regard the creditable actions of their fellows as having some sort of a claim to reward, and when we look into the nature of this claim, we find that its force rests upon the fact that we instinctively regard ourselves as in some way responsible for the behavior of others, and, consciously or unconsciously, take it upon ourselves to encourage them to act as they should act.

Now we not infrequently hear that, if the position taken by the determinist is right, our notions of the creditable or discreditable character of actions must be wholly erroneous. What the determinist really holds I have tried to make clear in an earlier number of this magazine.* He holds that human actions could be completely accounted for if we really knew all their antecedents. Among these antecedents he reckons the character, the inherent or acquired impulses, of the individual. It is only the fatalist that overlooks these, and fatalism is something very different indeed from determinism. The determinst maintains that the question: 'Why did this man act in this particular manner?' is never a foolish question, although we may in any particular instance be ignorant of the answer. He assumes that there is always some cause or causes that can account for the result. The 'free-willist,' on the other hand, maintains that no complete answer to such a question can be given, not because we are ignorant, but because human actions are not necessarily the results of causes. If we ask him: 'Why did this man elect to put his hand in his pocket and take out a copper for the beggar on the street?' he is capable of answering: 'Just because he did,' and this 'because' is no better than a 'woman's reason,' i. e., it is no reason at all. It amounts to asserting that, in so far as human actions are 'free,' they have no cause whatever, and the search for an explanation of their occurrence is wholly futile.

But what can induce any man to hold that we cannot regard actions as creditable in so far as they can be accounted for by antecedents of some sort, and that we must regard them as creditable only in so far as they are causeless? The position is one often enough taken, and probably there is no one of my readers who has done some reading in ethics who has not met with this opinion. It is clear that there is nothing in what I have said above about the credit we allow to good actions, that cannot be assented to by a determinist. He admits that men differ greatly in character, and that, in the same circumstances, two different men may act in very different ways. He admits that men's characters may change, and thinks it his duty to influence them to change in the proper direction. Rewards and punishments he regards as a part of the machinery which brings about the gradual moralization of the race. He sees no objections to distributing rewards where they will do the most good and the least harm; and he points to the actual practise of mankind in evidence of the fact that men generally have unconsciously embraced the principle upon which he insists, and do constantly act upon it. Yet the 'free-willist' maintains that he is wholly in error, and that credit and discredit must be allowed upon a very different principle. Does the 'free-willist' take this position 'freely,' i. e., for no reason at

* December, 1900.

all? or may we assume that he does so because it seems to him at least a plausible one? If he says what he does just 'because he does,' it is, of course, useless to argue with him. He is not what we call a rational being, and is not moved to embrace this or that conviction by evidence. But, being myself a determinist, I will be more generous with him than he is with himself, and will maintain that he is not so wholly unreasonable as he represents himself to be. I will look for some motive which may explain why he takes so strange a position.

A very little reflection upon what 'free-willists' have written reveals that that motive is not far to seek. It is the old confusion of indeterminism, or 'freedom' in a special sense of the word, with freedom in the usual sense, freedom from compulsion. No man in his senses thinks of praising or blaming any one for acts performed under compulsion. If a stronger than Tommy seizes his small hand, forces his fingers to close upon a key and turn it, pries open his mouth and fills it with jam, no sane parent would dream of punishing the involuntary offender. And if a stronger hand catches the boy as his fingers are stealing towards the lock, and drags him forcibly away from the fascinating spot, no one but a fool would regard the precipitate retreat as a triumph of virtue that calls for the crown of some substantial reward. It may or may not be a desirable thing to be born with red hair, but surely no one will maintain that it is a creditable thing. When he is acting under compulsion, Tommy's actions are no more a matter of choice than is the color of his hair, and we recognize this fact in judging him. On this point all classes of moralists are agreed—actions can be creditable or discreditable only if they are voluntary, or only if the actor is free.

We ought never to forget, however, that freedom in this sense of the word means only freedom from compulsion, a freedom to act out the impulses inherent in one's own nature. It is a totally different thing from 'freedom,' that philosophical fiction that has played so large a part in polemical literature. But it is easy to confuse things that pass by the same name, and when the 'free-willist' hurls at us the contemptuous question: 'Do you mean to assert that there can be any credit for actions which we do not freely do?' we too often make haste to affirm that there cannot be, without stopping to ask him whether he means the word *freely* to be understood with or without the quotation marks. He himself fails to perceive that the word is ambiguous; and seeing, as we all do, that only free actions are deserving of credit, he makes this true of 'free' actions. He thus comes to deny credit to every action that is not causeless. It is evident that he has no *good* reason for such an assertion, but he has at least *a* reason; he has simply fallen into a confusion, and to do this is human, while to embrace a doctrine 'freely,' or for no reason at all, appears positively inhuman.

We have seen that, from the point of view of the determinist, it seems an eminently reasonable thing to regard certain good actions as deserving of credit rather than others, and to strive to reward them. We have seen also that we can estimate roughly, at least, the amount of the reward that it is desirable to give. There appears to be nothing absurd, and nothing hopelessly mysterious in the whole matter, although our ignorance of human character, its impulses, the motives that can be expected to lead to this or that action, and, indeed, of the whole machinery of human life, is and must remain very great. But what if we adopt the hypothesis of the 'free-willist'? Let us suppose for the moment that actions can be regarded as creditable only in so far as they are 'free' or causeless, and let us see whether this will cast a brighter light upon the corner of ethics with which we are concerned.

The first difficulty which meets us is a seemingly hopeless uncertainty as to what actions are 'free' and the degree of their 'freedom.' We watch Tommy from a distance as he loiters about in the region of the pantry. Evidently there is a struggle going on within him. He advances his hand; he withdraws it; he takes a step forward; he looks about apprehensively; he touches the key; he stops to reflect. Finally he sighs, and walks away without having done the deed. Of what warring forces has his little mind been the theater? Were the combatants but two—love of jam and 'free-will'? Can we measure the amount of the latter by the degree of opposition which it has met and overcome in the former? Certainly not. Tommy has been whipped before for this offense. He has been talked to seriously on many occasions, and he is not a bad-hearted boy. Fear of detection may influence him more or less; the beginning of a love for virtue and a rather well-developed love of approbation count for something. He has within him a germ of self-respect. All these things are enlisted on the side of right conduct, and the potent influence of just such forces as these even a 'free-will' parent frankly recognizes. No philosopher who has had the fortune to have a son, and who has cared anything about him, has ever delivered him over bodily to the tender mercies of 'free-will.' He keeps prodding at 'free-will,' so to speak, in a more or less deterministic way. It may be his trump card, but he is never willing to throw away the rest of his hand. Accordingly, we must assume that the battle has not been a duel, but a general mêlée. What measure of credit can 'free-will' assume for the result? How shall we apportion our reward for the victory? Does the boy deserve *no* credit except in so far as he has acted 'freely'?

Moreover, how are we even to know which action should be rewarded? The determinist has no great difficulty in picking it out, for the mere sight of the struggle is to him an indicatioon that encouragement is needed and should be given. The 'free-willist' can, of

course, not regard the reward as an encouragement, for it is foolish to attempt to encourage 'free-will.' Could it be 'encouraged' it would evidently not be 'free.' And if this notion of encouragement wholly drops out, there appears no reason why actions performed after a struggle should be regarded as creditable rather than actions performed without any struggle at all. Suppose that Tommy has attained such a fixity of character that he can pass the pantry door twenty times without apparent effort. Does this mean that he has lost his love of jam? May it not mean that he is subject to such generous bursts of 'free-will' that all fleshly inclinations are overcome as soon as they are born? Then why should he not be rewarded more generously than before, when he had such dribblings of 'free-will' as scarce sufficed to bring him out of the combat alive?

It appears, then, that it is impossible to ascertain how much credit is to be allowed for any action, and that it is impossible to discover what actions are to be regarded as creditable. This does not seem encouraging, and may well tend to dampen our 'free-will' ardor. But we must pluck up our courage, for we are compelled to face a difficulty which is, if possible, more disheartening, Reflection discloses the fact that our theory forces us to deny the validity of the moral judgments that we have all our lives been passing upon our own actions and those of our fellows. This is so important a point that I must try to make it quite clear. It is a point passed over in silence by the 'free-willist.'

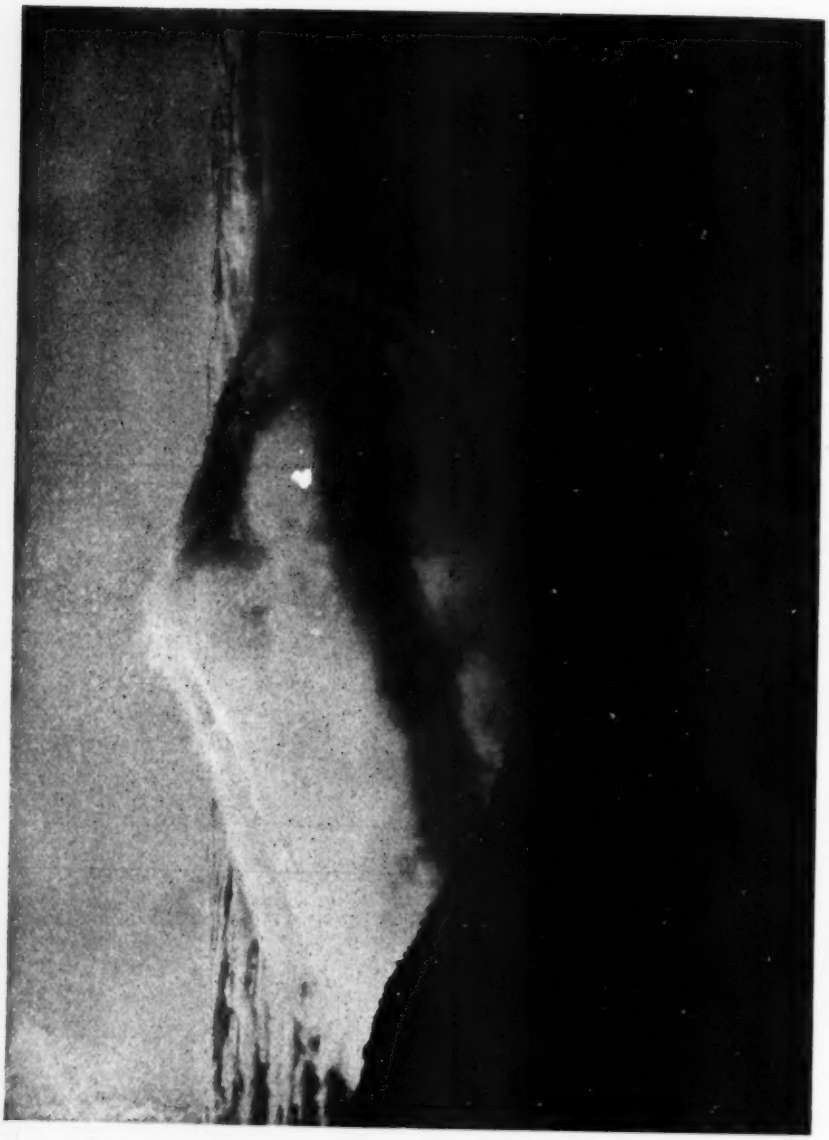
Let us suppose that Smith sees Jones struggling in the water, and makes desperate efforts to save him from drowning. His efforts are crowned with success, and Jones sits dripping on the bank, with a heart overflowing with gratitude. But he speedily discovers in Smith a creditor whose sole interest in the transaction was a pecuniary one. He saw his money drowning before his eyes, and he did his best to secure it. Does Jones now owe the man both money and gratitude, or does he owe him money alone? Let us suppose again that we have contemplated with satisfaction the temperate and orderly conduct of a young man whom we have regarded as exposed to divers temptations. We feared he was going to be dissipated, and we have been agreeably disappointed. We give expression to our pleasure, and he informs us frankly that the least rumor of misconduct would lead his uncle to disinherit him. 'Wait,' he says 'until the old man dies, and you will see my good time begin.' Do we, after this avowal, regard him as a model of virtue, and a youth to be held up as a pattern? No man rates as a philanthropist the scientific enthusiast who visits the sick with assiduity only in order to secure materials for his contemplated monograph on pain. Before we judge of human actions we try to find out something about their setting. We pry into motives and inquire regarding intentions. Precisely the same act may be good or bad, according to its context. It

is not a moral act for a savage to save a man alive if he is spared with the intention of fattening and eating him later.

Now let us suppose that the action under discussion is my contribution of a dollar to the hoard of the beggar on the corner. Is it a creditable action? Is it even a moral action? Only the unreflective will undertake to answer off-hand that it is. I may have given that dollar in the hope that one more drinking-bout would finish the beggar, and relieve me of his unæsthetic presence when I take my daily walk. I may have given it out of pure vanity, and to compel the admiration of the pleasing young person who is waiting for the tram. On the other hand, I may have given it because I was touched by the sight of suffering, and was willing to make a sacrifice for the sake of relieving it. It seems the most natural thing in the world to judge that the action was, in the last case, a creditable one, but was not creditable in the others. We have been judging of actions in this way all our lives.

But what if the act was a 'free' one? What if it was not determined by my character and impulses and the peculiar circumstances in which I was placed? In this case it cannot be explained by my desire to be rid of the beggar's presence. The impression made upon me by the fair onlooker cannot account for it. The sight of the beggar's misery furnishes no explanation. We cannot ask *why* the act was done. It was a *'free'* act. It simply appeared. It was not done for the sake of removing the beggar, tickling my vanity or relieving suffering; for just in so far as an act is 'free' it cannot be accounted for by any ideas antecedently in my mind or by my natural tendency to selfishness, to vanity or to generous movements of sympathy. It is, hence, an act without a setting—causeless, purposeless, blind. Is it a creditable act? Are such acts the *only* creditable acts? Surely we have turned our face resolutely away from the moral judgments of mankind when we have committed ourselves to the unnatural doctrine that only 'free' acts are deserving of credit.

It is quite inconceivable that men should with open eyes defend the doctrine of 'freedom' on moral grounds. When they attempt to do so, it is clear that they are really arguing in favor of *freedom,* a thing well worth fighting for, and dear to the heart of determinist and 'free-willist' alike. They have simply fallen into a confusion, and have confounded two things that are extremely unlike. I should be the last to maintain that the world could get on properly without philosophers, but I must frankly admit that the philosopher sometimes falls into error, and is very apt to take with him in his fall certain of the by-standers who, if left to themselves, would never have thought of tumbling into that particular ditch.



HELMHOLTZIAN FOG BILLOW, NAMED IN HONOR OF VON HELMHOLTZ, WHO FIRST DISCUSSED SUCH CONDITIONS.

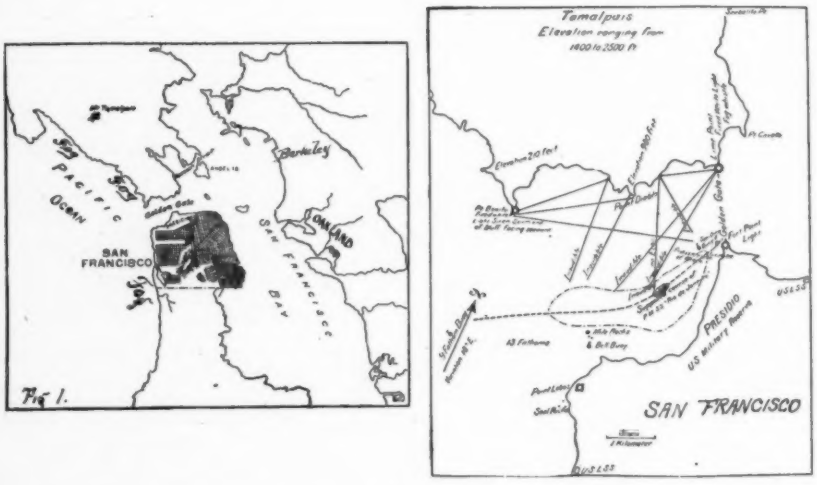
FOG STUDIES ON MOUNT TAMALPAIS.

By ALEXANDER McADIE.

LATE on a February afternoon the passengers on a large Pacific Mail steamship sighted the Farallones and doubtless thought as the pilot came aboard that the long run across the broad ocean not always true to its name was safely over and danger past. The 'Rio de Janeiro' came to anchor a little before six o'clock on Thursday night, February 21, 1901, and the weather being foggy, the captain wisely remained at anchor until about 4 a. m. when the fog lifted. The lights of the Cliff House two or three miles away could be seen and the vessel started on a northeast course with Lime Point dead ahead. There is some difference of testimony as to whether the Captain or Pilot gave the order to go ahead. The fog closed down again and the Pilot steered by the whistle hoping to get the echo from Point Diablo. No echo was heard. The vessel was not moving at full speed, the First Officer was standing on the starboard side listening for the Fort Point bell and the Captain and Pilot were on the bridge. No soundings however were taken. At about 5:30 a. m. the vessel struck the Fort Point Reef, backed off and within twenty minutes had gone from sight with 130 of the 210 persons aboard.

The two diagrams herewith show the general approach to the Bay of San Francisco and in more detail the probable path steered by the 'Rio' with zones of inaudibility of the fog signals.

When all is said and done it appears that the fog was the prime cause of this appalling accident. Now, while an accident of such magnitude gives startling emphasis to the need of studying fog, a summation of the minor accidents for a single year due to fog in any large seaport would be equally impressive. One cannot cross the sea, run down the coast or even go over a bay upon a ferry-boat without experiencing at times this troublesome condition. Nor is it only when on the water that we are at the mercy of the fog. Study the statistics of railway accidents and you will be surprised how often, in the column giving the cause of collision or other accident, the word fog appears. Can we help ourselves? Yes; and the first step is to study patiently and systematically the various types of fog formation. Already the ability to communicate by means of wireless telegraphy between vessels at sea and the land removes the greatest element of danger to vessels caught in fog. The 'Rio de Janeiro' was lost at the entrance to

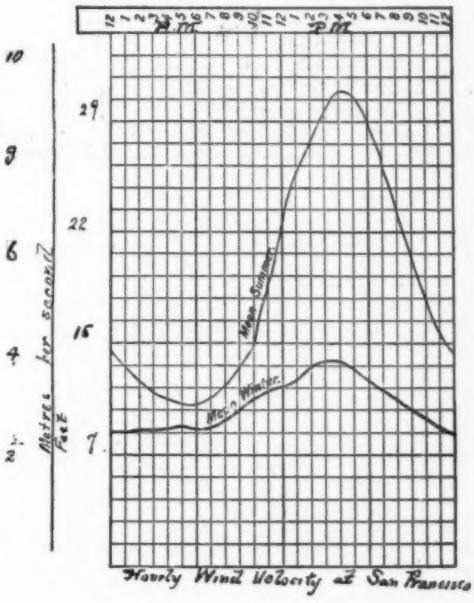


THE REGION ABOUT SAN FRANCISCO AND PROBABLE CONDITIONS AT TIME OF WRECK.

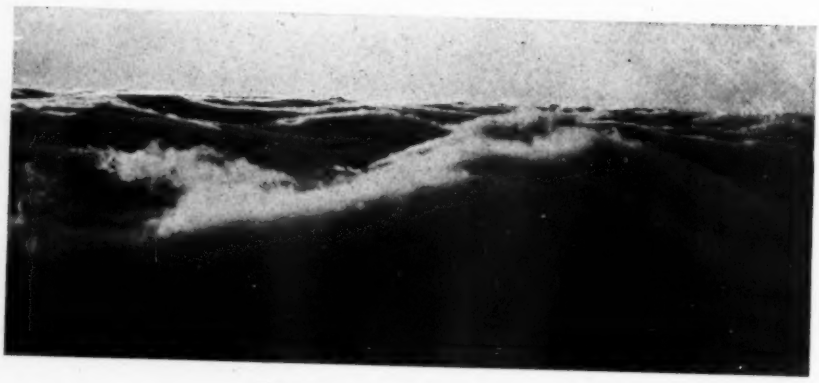
PROBABLE COURSE OF 'RIO DE JANEIRO.'

what might have been thought to be a well-protected harbor. That is, there were light-houses and fog whistles along the shore, but the vessel was helpless, nevertheless, when the fog closed down, for all guiding points were lost and, owing to the peculiar reflections and refractions of sound waves in the air, the whistles and bells, as the accident too sadly proved, were inaudible.

In the vicinity of San Francisco the processes of cloudy condensation in the free air are very active. It is no uncommon occurrence on summer afternoons, when the wind is blowing at the rate of twenty-two miles an hour, to see sharply marked fog drifts hang like white blankets over the city hills or stream through the Golden Gate like a spectral army. From the U. S. Weather Bureau Observatory on Mount Tamalpais, elevation about 2,400 feet, one looks down upon such remarkable fog formations as are shown in the accompanying illustrations.

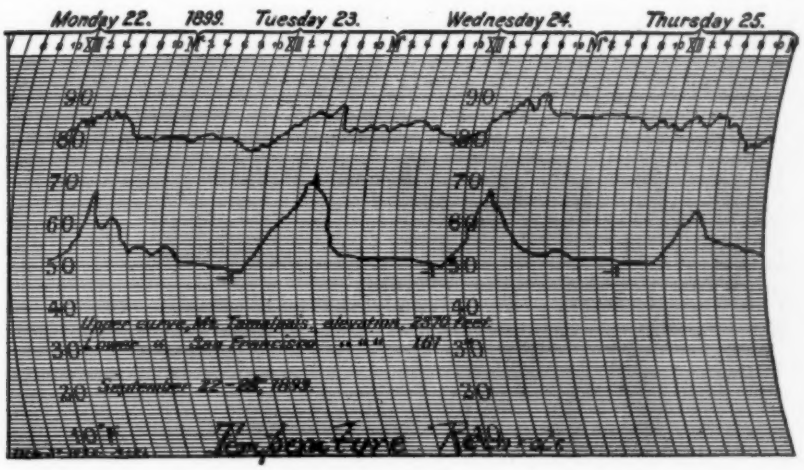


Now fog, like frost, may be considered to be largely a problem in *air drainage*. The condensed vapor, like the frozen vapor, indicates air motion with certain accompanying changes in temperature. Therefore the first line of study in connection with fog formation is concerned with temperature gradients; and chiefly the vertical gradient. Instead of the usual fall in temperature of 1° for each 183 feet elevation, we find in these San Francisco fogs an increase of temperature from sea-level upwards. In a given summer month the mean daily temperature at the upper station was eleven degrees or more warmer than at the lower station. If the rate of increase were uniform throughout the 2,500 feet, this would mean a rise of one degree for two hundred feet elevation. The rate is not uniform, and between the 1,500 feet and 2,000 feet levels is probably often as much as one degree for fifty feet. Days without fog are as a rule days without this steep inverted gradient, and it would seem as if the temperature throughout the entire mass of air was more uniform. Some approximate vertical sections of the temperature in a fog bank were obtained by carrying a Mar-



FOG STUDIES FROM MOUNT TAMALPAIS.

vin meteorograph from the summit to the valley and back, the descent and ascent requiring about 100 minutes, the distance being about 16 miles. The instrument was hung at the top of an open canopied car in such a way as to secure a good air circulation. The average dew-point was 50° F. (10° C.) and the maximum weight of a cubic foot of water vapor at this temperature and saturation 100 per cent. is a little over 4 grains. Estimating an average fog bank as covering an area of fifty square miles and extending from the 500-foot level to the 1,500-foot level, the maximum weight of the water vapor would be about 400,000 tons; and if this condensed vapor could be suddenly precipitated it would be the equivalent of a rainfall of about one-tenth of an inch. But condensation and precipitation are not identical. The processes



TEMPERATURE RECORDS.

which cause the collapse, if it may be so called, of a cloud of fog are obscure. Elaborate experimentation is needed at this point before the problems of fog dissipation or rain-making can be solved. With the fogs of the San Francisco Bay district and indeed with every dense cumulo-nimbus or cumulus cloud, the condensation is considerable and it would seem at times as if but a very gentle initiative would lead to precipitation. Various methods of removing dust particles from the atmosphere have been suggested within the past few years, and possibly in thus removing the dust the essential nuclei of condensation may be removed. Conversely, in order to bring about precipitation, it may be found necessary to supply at the proper time the proper nuclei. At any rate, it is known that by various methods, of which may be mentioned filtering, clarifying, recondensing, calcining and electrifying, smoke, fog, dust and condensed vapor may be removed from limited spaces. The

removal of the fog for even a small distance in the neighborhood of a fog-bound vessel might be of advantage. The chief difficulty at present would seem to be the quick influx of the circumjacent fog. The supply of fog might be so great that our dissipators would seemingly produce no effect. The dissipation of fog and smoke in enclosed areas by electrical agencies, as strikingly shown in Dr. Lodge's experiments, leads to the wish to reproduce these experiments in the free air and upon a large scale. Moreover within the past two years there has been growing up a theory due chiefly to Zeleny, Elster, Geitel and T. C. R. Wilson concerning the part played by ions in causing rain. It is known that the negative ions move more rapidly than the positive ions and that water vapor will condense more readily on the negative ions. It may

SUNSET OVER A SEA OF FOG.

be that under certain unstable conditions some of the more energetic ions, by relieving the electric tension, inaugurate the formation of the rain-drop. In studying the electrical potential of the atmosphere, it has been shown that the approach or retrocession of clouds, especially cumulus and cumulo-nimbus, could be determined by the changes in the potential values. There was also good reason for believing that the electrometer gave in certain fluctuations indications of the proximity of invisible vapor masses. Certainly the one instrument upon which we now rely in studies of fog formation and influence, the mercurial thermometer, is far from being a sufficiently sensitive instrument. Optical methods may furnish apparatus sufficiently delicate. It has

been claimed by some that the polarization of blue sky light can be used in studying the vertical distribution of fog, and that changes in atmospheric conditions are shown by this means several hours in advance of other precursory appearances.

Strangely enough within the past year and from an unexpected source, suggestions have been made which should be considered with some care and then tested. In discussing the mortar batteries used at Windisch Feistritz, Dr. Pernter has given us some data concerning vortex rings. These are the rings which, according to Burgermeister Stiger and his associates, successfully protect their vineyards from hail. Whatever the real cause may be regarding hail, we are thankful for the opportunity to study such large and energetic vortices. These rings are powerful enough to tear a thick paper screen to pieces at a distance of 100 meters. On leaving the mortars in a horizontal direction the whirls have a velocity of about 170 miles per hour or eight times the velocity of the stiff surface indraft of air on summer afternoons through the Golden Gate. At a distance of 100 meters the velocity was reduced nearly 50 per cent. With the Suschnig apparatus, the charge of powder being 250 grammes, Dr. Pernter found an initial velocity of about 55 meters per second. The probable limit of upward movement was 400 meters. Dr. Hann has suggested that the results obtained by shooting these rings into winter fogs should be carefully studied. The suggestion is pertinent. At Mt. Tamalpais, as we have tried to show, unusually good opportunities exist for experimenting upon fog. Many varieties of formation occur. The tule fogs of winter, in one of which the 'Rio de Janeiro' was lost, sometimes do not exceed 100 feet in depth. The summer afternoon sea fogs are more dense and more sharply defined. Some of the fogs are due to direct cooling by contact; in some the cooling is due to radiation, and, in the great majority of cases, the cooling is due to mixture. The differences in temperature, humidity and air motion are so marked that it is likely that differences in electrical potential, dust-content and ionization also exist. There is urgent need of bettering our knowledge of these matters. Practical applications will speedily follow.

The sacrifice of life on that ill-fated steamship on the morning of February 22 will not have been altogether in vain, if it leads to a thorough study of the conditions governing fog.

THE FRENCH SARDINE INDUSTRY.

By Dr. HUGH M. SMITH,

U. S. COMMISSION OF FISH AND FISHERIES.

AMONG the foreign fishery industries on which Americans are dependent for a part of their food supply, few exceed in interest or importance the sardine industry of France. The value of the French sardines imported into the United States is about one million dollars annually, and the wholesome, palatable and convenient canned sardine is consumed in nearly every community. The accompanying notes on the sardine and the industries to which it gives rise are extracted from an article in the 'Bulletin' of the United States Fish Commission for 1901, based on the writer's personal observations in Brittany, the principal center of the sardine fishery.

The sardine is the leading fishery product taken in the waters of France. From official statistics it appears that in 1898 the sardine fishery gave employment to 31,871 fishermen; the number of boats used was 8,164, valued at 5,934,633 francs; the apparatus employed was worth 7,030,945 francs; the quantity of sardines taken was 53,924,275 kilograms (or 118,633,400 pounds); and the selling price of the fresh fish was 9,204,988 francs (or about $1,840,997).

There exists considerable uncertainty among the fishing interests and the general public in America and Europe regarding the sardine of the Bay of Biscay and the Mediterranean Sea. Some persons have believed that the sardine canned in France is a distinct species, while others have held that the French sardine, like the sardine of New England, is simply the young of some herring-like fish. The term sardine is a general one, applied to various clupeoid fishes, mostly of small size, in different parts of the world, and can not be restricted to any particular fish. Thus, there are the Spanish sardine of the West Indies and Florida; the California sardine, found along the entire west coast of the United States; the Chile sardine; the oil sardine of India; and the sardines of Japan and New Zealand. But the sardine *par excellence* is the French sardine, called also celeren, celan, royan, galice and cradeau on various parts of the French coast. The name sardine has reference to the island of Sardinia, in the Mediterranean, about whose shores the fish is abundant.

As early as 1553, Pierre Belon, a French naturalist, asserted that the sardine is the young of the pilchard; and this is the view now held

by nearly all authorities. The pilchard, as is well known, is one of the most important fishes of the southern coast of England, being especially abundant in Cornwall. Young pilchards or 'sardines' are found on the Cornish coast, but are apparently not so numerous as in France and are in little demand, as canning is very limited in extent; on the other hand, large sardines or pilchards are caught on the French coast, but are much less abundant and less important than the small fish.

In allusion to the small sardine being caught almost wholly by means of bait consisting of fish roe (rogue), the French call it *sardine de rogue,* in contradistinction to the large fish which is taken without bait by means of drift nets, and hence called *sardine de derive.* Modern French writers on the sardine fishery seem averse to acknowledging the specific identity of the sardine and the pilchard; some even fail to explain or suggest the relation between the large and small fishes of the west coast of France.

The pilchard is a well-marked species, easily distinguished by prominent radiating lines on the operculum and by large scales, as well as by other features. The usual length is eight or nine inches; the length of the largest recorded specimen was fourteen inches (taken in Cornwall). The sardine of the French coast is a handsome little fish, whose beauty is not entirely lost in canning. In the water the back is of a greenish color, but out of the water the upper parts are rich dark bluish, contrasting strongly with the silver and white of the sides and abdomen. The scales are very easily detached, but their loss does not detract seriously from the appearance of the fish, when either fresh or canned, as the skin is rather thick and has a brilliant uniform silvery color.

PILCHARD OR SARDINE (*Clupea pilchardus.*)

The range of the sardine extends from Sweden to the Madeira Islands. The southern coast of England, the Atlantic coast of France, and the Mediterranean Sea are the chief centers of abundance.

On the coast of Brittany the *sardine de rogue* is found about nine months of the year, being absent from the inshore waters most of the winter. When the fishing season opens, the fish are reported first at Arcachon and other southern points on the west coast, and gradually reach the districts toward the north. During the winter, however, the

large fish—some a foot in length—are observed at various places on the coast.

The immature sardines frequent the coast waters throughout the summer and remain in Brittany until late in fall. Some years, if the season is mild, they are caught until the first or second week in December, but a storm coming any time in November is likely to drive them away and terminate fishing for the season. In 1900 sardine fishing at Concarneau was ended November 5— the same date as in 1899 —by a southwest storm, which swept away all the sardines in the bay.

The spawning time on the coasts of England and France is from June to October. Spawning takes place at a considerable distance from the land, and ripe or spawning fish are seldom caught, as fishing is done mostly in the inshore waters. The small fish used for canning purposes on the French coast are never found with ripe eggs or milt, and are now known to be immature fish hatched in the summer and fall of the previous year. The eggs are buoyant, and the average number extruded is reported as 60,000. In the Mediterranean the sardine apparently belongs to a different race, which is smaller than the oceanic form and reaches maturity when under 7 inches in length.

When sardines first arrive they are poor and unsuitable for canning; but as the season advances they improve in quality, and are fatter in September than in June and in December than in September. Their food consists mainly of copepods and other small crustacea. Small fish eggs are also a favorite food. The fondness of the sardine for such eggs plays an important part in the fishery.

The sardines go in schools and swim at or near the surface. As many as 100,000 fish have been taken in one net from one school, but the usual catch is much less. They are preyed upon by cetaceans and by many fish—the mackerel, the haddock and the dolphin being especially destructive on the French coast.

Like other free-swimming oceanic fish, the sardine varies in abundance from year to year; but there is no evidence that the fishing is effecting any permanent reduction of the supply. During the years 1887 to 1890 there was an alarming scarcity of sardines on the French coast, and the outlook for the industry was serious, but after four years the fish returned in their former numbers. The history of the sardine fishery shows what extensive operations may be supported annually when the natural conditions permit the fish to spawn unmolested, the spawning grounds in this case being many miles offshore.

Several American fishes resemble the pilchard, among them the sea herring and the California sardine. The former is extensively canned on the coast of Maine, and often placed on the market as 'genuine French sardines in pure olive oil'; the latter is canned to a limited extent in southern California.

The sardine fishery of France dates back many years, and even in the early part of the eighteenth century was an important industry, but it has become much more extensive since the introduction of canning. The building of railroads has also benefited the fishery by providing means of shipping to the inland points that part of the catch which can not be disposed of locally.

SARDINE FISHERMAN'S HOUSE, BRITTANY.

The province of Brittany supports by far the most productive fisheries and is the center of the canning industry. Here in 1898 were 21,684 fishermen, with 4,611 boats, and here were caught 49,478,365 kilograms of sardines, selling at 7,572,347 francs. The leading center is Douarnenez, which is credited with 4,200 fisherman, 710 boats, and over 18,000,000 kilograms of sardines, valued at 2,442,000 francs. Next in importance is Concarneau, with 2,695 fisherman, 490 boats, and 9,163,000 kilograms of sardines, worth 1,719,890 francs. Other important places in Brittany are Audierne, Quimper, Port Louis, Etel, Quiberon, La Turballe and Le Croisic. Outside of Brittany the fishery is most extensive at Sables-d'Olonne, St. Gilles-sur-Vie and Arcachon. On the Mediterranean coast of France sardines are caught at numerous places and by many fisherman, but only in relatively small quantities. The fisheries here in 1898 gave employment to 7,794 men, using 2,861 boats, the catch being 2,129,519 kilograms, valued at 987,738 francs.

Formerly in parts of Brittany nets were used to surround the schools and then stones were thrown in to frighten the fish into the

meshes. In this way large catches were often made and the market was glutted; but the method came into disrepute and is no longer followed. Fishing is now carried on exclusively with gill nets, made of very fine cotton twine; they are 45 yards long and 500 meshes deep, and are kept in position in the water by numerous cork floats and a few stone sinkers. The mesh is necessarily very small, as it is intended to gill the tiny sardines. The nets vary in fineness to suit the different runs of sardines, and are of about three standard sizes. The largest mesh is equal, in America, to 0.66 inch, bar measure, while the smallest size equals 0.40 inch. The complement of each boat is 10 nets, representing the three sizes of mesh.

The nets are dyed a bright greenish blue, and when suspended from the masts to dry add to the picturesqueness of the fishing boats and the wharf scenes. The dyeing is for the twofold purpose of preserving the nets and rendering them less conspicuous when in the water.

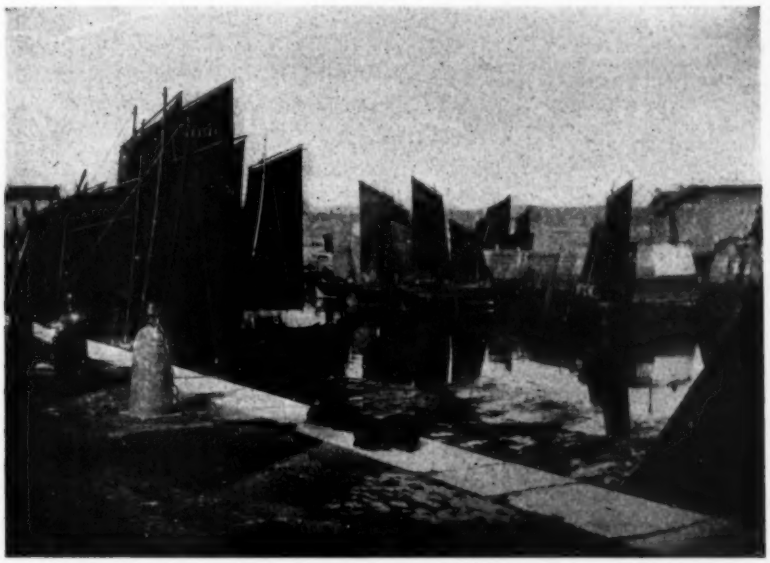
In the fishery for sardines for canning, bait is almost as important as the boats and nets. In no other net fishery in the world is bait so extensively employed and so essential to the success of the industry. The scarcity of bait is always a serious matter in the fishing districts, curtailing the catch, reducing the income of the fisherman, and often producing distress among the fisherfolk. It is therefore remarkable that for this indispensable article the French should be absolutely dependent on other countries and that the success of the fishery for sardines should be intimately related to the fisheries for other species in distant lands.

In the early days of the sardine fishery, especially prior to the establishment of canneries, small shrimp-like animals, about half an inch in length, were much used as bait. The gathering of this kind of bait was an occupation of the women, who sought the schools in the bays and coves, catching them in large canvas bag-nets. They frequently made their best catches in water up to their necks, when the weather was bad and the water along the shores was thick. The taking of these little creatures appears to have been prohibited many years ago, because of the supposed destruction of the eggs at the time of catching the shrimps. Although the interdiction is now removed, little effort is made to secure this form of bait.

The bait now in general use is the salted eggs of the cod, though the eggs of hake, haddock, pollock, cusk, herring, mackerel and many other fishes are also employed. Cod eggs are not known to possess any properties which make them superior to the eggs of several other species, but owe their prominence to the abundance of cod in regions on which the sardine fishermen depend for their bait supply. The annual consumption of roe in France at present is 40,000 to 45,000 barrels, for which the fishermen pay about $300,000. It is reported that in favor-

able seasons as many as 25,000 barrels of roe have been expended in Concarneau alone.

For at least two centuries cod roe has been imported from Norway, which country has always furnished the greater part of the sardine bait. Other countries which have contributed supplies are Holland, Newfoundland and the United States. From time to time the French Government has encouraged its own cod fishermen (at St. Pierre and Miquelon; on the Grand Banks; in the waters of Iceland, and in the North Sea) to preserve the roes of cod and other fish, and in 1816 offered a bounty of $4.00 a barrel for roe made from fish caught by them; but this and other inducements have had little effect on the supply from native sources.



SARDINE BOATS IN THE HARBOR OF CONCARNEAU.

The price of roe has varied greatly from year to year. In the early part of the eighteenth century, bait was bought for 50 cents to $1.00 a barrel, and throughout that century prices were comparatively low. In the second decade of the last century prices reached their highest point; they were apparently never less than $32.00, and ranged from that to $60.00 per barrel. By 1822 the price had fallen as low as $5.00 or $6.00, and since then has seldom been as high as $25.00 or $26.00, averaging $12.00 or $15.00 The average price for Norwegian roe recently has been about $7.00 per barrel. In 1900, owing to the failure of the Norwegian cod fishery and the resulting scarcity of roe, the price for Norwegian bait rose to $24.00 per barrel. The price of

American and Newfoundland roe is but little more than half that of Norwegian. In 1900 the best American roe was selling at $8.60 a barrel and in the previous year at only $4.60.

The sardine fishermen use peanut meal or flour to mix with the roe, it being much cheaper. Floating lightly and being quite conspicuous, it attracts the attention of the sardines, which readily devour it.

In the Mediterranean sardines are caught during every month of the year. On the west coast, however, the fishing season opens in February and continues to November, rarely extending into December. Fishing in the canning districts is continued as late as practicable, usually as long as the fish remain in abundance, as their condition at that time is good.

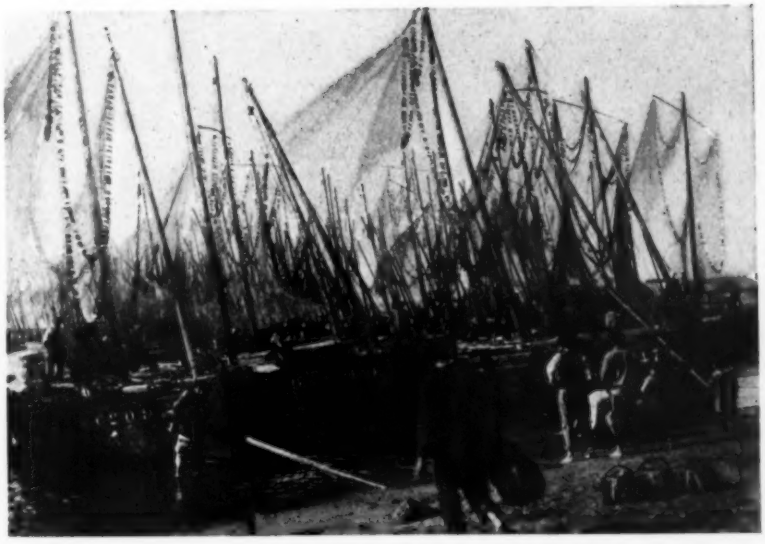
The sardine fishery is emphatically a shore fishery, and most of it is done within a very short distance of the home ports. This permits the use of smaller and less expensive boats than would otherwise be required, and insures the landing of the fish a short time after capture. The early fishing for the *sardines de derive* is mostly within 1 or 2 miles of the shore and rarely beyond 5 or 6 miles. In the summer and fall fishing with bait, the boats may go 10 miles to sea, but the largest part of the catch is taken within 3 or 4 miles of shore, and a very considerable proportion close inshore in the bays.

The fishing in the early part of the season— that is, in March, April and May—is done mostly with old nets and is conducted only at night. While the boats are lying near by and the men sleeping, the nets are allowed to drift. No bait is used. The fish thus caught are not fat and are not used for canning, but are salted or sold for immediate consumption. The regular fishing is carried on only by day. The boats start for the fishing-grounds early in the morning (2 to 4 o'clock), so as to be there when day breaks. They may also have to leave earlier if the tide would otherwise beach them. The best fishing is in the early morning, and the boats are often back to port by 9 or 10 o'clock with full fares.

When a boat arrives on the fishing-grounds, a net is shot and slowly towed by means of a short line attached to the cork line and fastened in the stern of the boat. In summer fishing, when sardines are abundant, the fishermen often let one net go adrift when it is full of fish, trusting to pick it up later, and put out another net. Indeed, a boat may have fish in three nets at one time, though this is rarely the case.

Bait is always used in the day fishing, being necessary in order to attract the fish to the vicinity of the boats and into the nets. The casting of the bait, on the proper use of which a great deal of the success of fishing depends, is always done by the master or 'patron,' who stands in the stern of the boat on a little platform and uses the flour and roe

SARDINE BOATS SAILING FOR THE FISHING-GROUNDS.



A GLIMPSE OF THE CONCARNEAU SARDINE FLEET, DISCHARGING THE DAY'S CATCH.

as required. When the fish have come toward the surface and are on one side or the other of the net, his object is to cast the bait in such a way that they will rush against the net and become gilled.

Considerable skill and experience are of course necessary in managing the net and in having it hang properly in the water and not become folded or wavy owing to currents or tide. Unless the net is straight or gently curved, the fish will see and avoid it. When a net contains fish and is ready for hauling, it is taken in the boat and the fish are removed from the meshes by gently shaking the net.

The sardines are often found in a compact body, and the boats will be concentrated in a comparatively small area, at times so close together that the operation of the net would seem almost impossible and the chance of catching fish very improbable. The entire fleet of a given

FISHING BOATS ON THE SHORE, CONCARNEAU.

port—consisting of several hundred boats—may be at work on one school and fishing literally *en masse* instead of individually.

No ice or other preservative is used on the fish, which are landed a short time after gilling. The fish reach port in good condition, and are often at the canneries within one or two hours after capture. Should the failure or unfavorable direction of the wind threaten to delay the arrival of the boats, and hence impair the quality of the fish, the crews row leisurely back to the port.

Soon after reaching port the nets are spread for drying, being hauled to the top of the masts and suspended between them for this purpose. When all the fleet has arrived and the nets are spread, the view of the maze of blue nets, sails and masts is most interesting and unique.

When the fishing boats begin to arrive, the wharves, which have practically been deserted, assume a very busy and animated appearance, and as the arrivals increase in number the bustle among the different classes of people becomes intense, although good nature and good order prevail. The foreign visitor here witnesses some exceedingly interesting and picturesque fishing scenes—thousands of fishermen in their coarse blouses and flat cloth caps, with trousers rolled up and their feet bare or in the huge wooden shoes of the country, unloading their fish and carrying them to the canneries; hundreds of women and girls in short dark skirts, white caps and collars, and wooden shoes, negotiating for sardines, receiving the fish from the fishermen, and dispatching them to the canneries; sardine boats, either rowed or sailed, entering the harbor in groups or singly and coming up to the already congested docks; fish wagons going to and from the factories, and a mixed crowd of merchants, sight-seers, artists and idlers. The commingled noise of waves, boats, wagons and tongues is underlain by the incessant rattle of wooden shoes on the stony pavements.

The prices received by the fishermen are regulated by the factory operators, and depend on the supply, the size and quality of the fish, the weather and other considerations. The fish of each boat are virtually sold at auction, only there is as a rule no counter bidding, the prices offered by one or two factories being adopted by the others and accepted by the fishermen. If a fisherman is not satisfied with the price offered by one factory, he is at liberty to seek a higher price elsewhere. Some boats always sell their catch to the same factory, and all of them, to a greater or less extent, deal with particular factories. The maximum price which factory operators can profitably pay for sardines is $5.00 per 1,000 fish. The dealers in fresh sardines can pay as much as $7.00 per 1,000. At times the demand for sardines to be sold fresh *(au vert)* tends to keep up the prices; but this use is limited and does not interfere greatly with the cannery demands.

Women usually represent the factories as purchasing agents. They are given considerable discretion by their employers and are very sharp in making bargains. Payments are not made in money, but in tokens or tickets which are redeemed weekly. As the fishermen deliver their fish, two baskets full at a time, to the agents of the canneries, they receive a metal tag or token with the name of the buyer on it. When all the fish are landed the metal pieces are counted and surrendered, and a claim check is issued in their place. At the end of each week the master or the owner of the boat (sometimes the same person) goes to the factory, receives the money due, and apportions the earnings of the crew.

The division of the proceeds of fishing is rather complicated. The boat, nets, equipment and bait usually belong to a nonfisherman (who

may own a number of boats). The men of the crew furnish their own food, fuel and clothing. The owner is entitled to half the sales of fish, and the remainder goes to the crew in the following proportions: There being 6 men in the crew, 4 of them get equal parts, the captain receives the share of one man plus 10 per cent. and the cook half a share. Dividing the proceeds into 22 parts, the boat owner is entitled to 11 parts, 4 members of the crew to 8 parts, the master to 2 parts and the cook to 1 part; the share of the master being increased by 10 per cent. of 2 parts and that of each member of the crew diminished by 2½ per cent.

From the time the men begin to fish until the close of the season, they pay to the government 1.10 francs per month, in consideration of which they are pensioned on attaining the age of 50, provided they have served 300 months on sea duty (either in fishing or in any other maritime occupation). They also pay 1.50 francs per month as premium on an insurance fund which the government allows for injury due to the vicissitudes of sea life. In case of death, the family of the fisherman receives an annual pension depending on the size of the family and on age and length of sea service of the deceased, the minimum sum being 300 francs; naval service increases the pension.

The average stock per boat in a given season varies greatly on different parts of the French coast, depending on various local causes besides the abundance of fish, such as weather, bait supply, local demand, shipping facilities, energy with which fishing is prosecuted and other evident factors. The boats fishing out of Brittany ports have a larger average yield than those of other ports of the west coast; and those in the Mediterranean have by far the smallest stocks. Thus, in 1898, the average catch per boat was about 10,700 kilograms of sardines in Brittany, 3,300 kilograms in the southern part of the Bay of Biscay and only 745 kilograms in the Mediterranean.

The construction of the first sardine canning establishment dates from about 1845, since which time the growth of the business has been almost uninterrupted. The factories gave to the sardine fishery a great impetus, and to-day are the chief supporters of the very extensive fishing operations in the Bay of Biscay. They employ many thousand persons, at what are considered good wages, and in some of the fishing towns give work to practically all able-bodied persons who are not engaged in fishing. In Concarneau, a town of 10,000 people, fully 3,000 men, women and children are directly connected with the sardine canning business, besides the fishermen. Most of the work in connection with the canning of sardines is done by women and girls, a few men being employed for special duties for which women are not adapted. The factories are generally large stone structures surrounded by a stone wall and inclosing a courtyard. Some are able to utilize

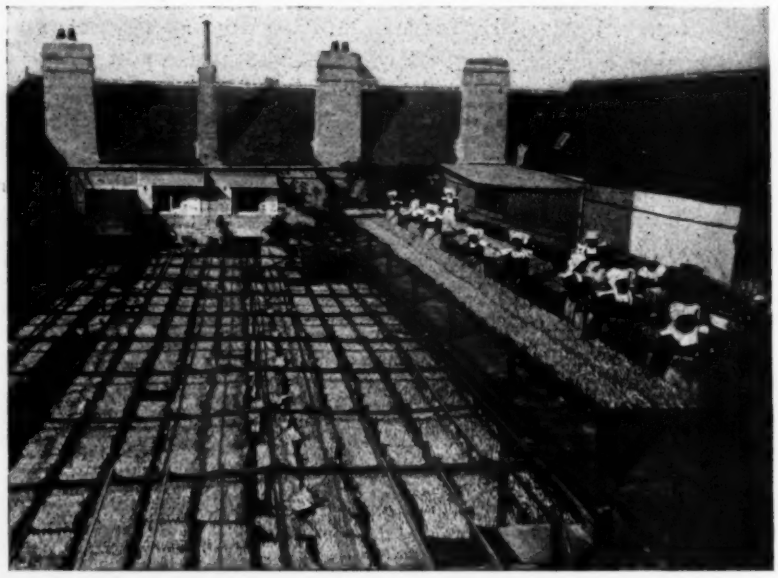
upward of a quarter of a million of fish daily. The yearly output of individual establishments is from 300,000 to 4,000,000 or 5,000,000 boxes. No complete statistics for the canning industry are available, but over 100 factories are operated and not less than 15,000 persons are employed therein. Concarneau and Douarnenez have more factories than any other localities, the number operated in 1900 being 29 and 25, respectively. A large number of the canning establishments are owned or leased by companies having headquarters at Bordeaux and Nantes.

The various processes to which the sardines are subjected in the course of canning may now briefly be noticed. As soon as the fish reach the factories, their heads and viscera are removed by women, who perform their work with great rapidity. The fish are then sorted by size into large tubs of strong brine, where they remain for about an hour. They are then placed in small wicker baskets and washed in either fresh or salt water for a few seconds, to remove loose scales, dirt and undissolved salt.

Drying, the next step, is done preferably in the open air, and a large part of the product is so treated. For open-air drying the fish are arranged by hand, one by one, in wire baskets or trays, holding about 150 fish of medium size, placed on wooden frames or flakes. The distinctive feature of the trays is their division into about 7 V-shaped crosswise compartments, in which the sardines are placed in regular rows, with their tails upward, so as to promote the escape of water from the abdominal cavity. The sardines remain out for a variable time, depending on their size, the state of the atmosphere, etc. The usual time in favorable weather is one hour. In damp, foggy or rainy weather the sardines must be dried indoors by artificial heat, and drying ensues much sooner than in the open air. Some factories, not being provided with driers, are unable to operate in such weather. In most of the factories, especially those more recently constructed, artificial heat is supplied in a special drying chamber by means of steam pipes.

From the drying flakes the fish are taken in the same wire baskets to the cooking room and immersed in boiling oil, in open vats of various sizes and construction. As the fish are quite dry, much of the oil is taken up in cooking and has to be replaced from time to time by fresh oil. The immersion in oil usually lasts about two minutes, but varies with the size of the fish and is best gauged by experience. The baskets are first removed to a table or platform with an inclined metal top, where the surplus oil is allowed to drain from the fish, and then taken to the packing room. There the sardines are carefully placed in tin cans. After the cans are sealed, they are immersed in boiling water for several hours; this accomplishes a fourfold purpose: (1) The

GROUP OF EMPLOYEES IN YARD OF A CANNERY, BRITTANY.



SARDINES DRYING ON GRILLS IN YARD OF CANNERY.

cooking of the fish is completed; (2) the bones are softened; (3) the bacteria in the oil and fish are killed; (4) the presence of leaks in the cans is disclosed. After cooling, the cans are placed in dry sawdust and stirred from time to time; this absorbs the oil and moisture on the surface, and renders the cans clean and ready for packing.

The sardine manufacturers ostensibly employ only two kinds of oil in their canning operations—olive oil and arachide or peanut oil. Native olive oil is used with the best quality of sardines. Fish packed in it will remain in good condition ten years or longer, and are reported to be better the second year after packing than earlier. Arachide oil is extensively employed. It is made in Bordeaux, Fecamp and Marseilles from peanuts imported from India, Senegal and other parts of Africa, and other countries. It comes in three grades, the best quality costing less than one-third as much as the best olive oil. Peanut oil is largely used to meet the American demand for a low-priced sardine. Most of the cheaper French sardines exported to America are packed in peanut oil, which is practically tasteless. While it is reported that the manufacturers knowingly handle only the oils named, it is understood that cottonseed oil, being tasteless and cheap, is used by the French oil-dealers for adulterating both olive and peanut oils. A canner may fry his sardines in peanut oil and fill the cans with olive oil, or vice versa; or one oil, with or without the admixture of cottonseed oil, may be used throughout the process.

There are various other ingredients with which or in which the sardines are packed to give them flavor or piquancy. Some of the very best goods are prepared with melted butter instead of oil; these are mostly for special French trade. Tomato sauce, pickles and truffles are also used. With most of the oil sardines a small quantity of spices is added in order to impart a flavor. The usual ingredients for each can are 1 or 2 cloves, quarter or half of a laurel leaf, and a small piece of thyme; these are put in the can before the fish, so that they will be on top when the can is opened. The fresh leaves of tarragon are sometimes used.

Americans need hardly be told that French sardines, when of the best quality, have a flavor and richness which make them preferable to the sardines prepared on the Atlantic coast of the United States from the young of the sea herring. French sardines of average grade, even when canned in peanut and cottonseed oil, are superior in palatability to the great bulk of the American output; while the cheaper grades of French sardines—which unfortunately find a ready market in the United States—are certainly not preferable to much of the native pack.

The conditions which underlie the general superiority of the French canned sardines, and the steps which may be followed in America for

narrowing the gap which now separates the products of the two countries, appear to the writer to be chiefly as follows: (1) The methods adopted in the French sardine fishery result in the landing of the fish in excellent condition. This is the main object and is never lost sight of. The fish are caught singly in a delicate mesh, removed by hand, carefully kept on board the boats so as to avoid crowding and mashing, counted by hand into small baskets, taken to the factories within a few hours after being caught, and promptly put through the preserving process, so that ordinarily the deterioration which ensues is not worthy of mention. (2) In France the sardines caught in the early part of the season are not canned, because they are not in the best condition. It is only after the fish have become fat that they are considered suitable for canning. The fattening depends on an abundance of proper food, and along with it is an improvement in the flavor and general quality of the flesh.

While the young sea herring is an excellent fish, it may be admitted that even when at its best its meat is inferior to that of the fat young pilchard in richness. The latter has a peculiar flavor which, to a considerable degree, is preserved in canning and which probably can not be successfully imitated in the sea herring. However, the difference in flavor between the French and the American sardines on which many persons lay much stress appears to the writer to be of only secondary importance. The taste for French sardines has been acquired and perpetuated in the United States because of the long-continued unsatisfactory quality of American sardines. The herring is naturally no less wholesome than the pilchard. If it is caught for canning only when in prime condition, and if, in the form of canned sardines, it is placed on the markets with the minimum amount of deterioration and with such adjuvants in the way of oil, spices, etc., as may be suitable, it should and will receive ample recognition at home, and meet with a constantly increasing demand at prices that are now hardly dreamed of.

The history of a few canneries on our east coast during recent years has shown that a very marked improvement in the quality of American sardines is entirely practicable, and, furthermore, is highly appreciated by consumers, as evidenced by the much higher prices they are willing to pay and the steady demand beyond the capacity of the factories. With regard to the sardines of the Pacific coast of the United States, there is no reason why they should not, when properly canned, prove equal to the French fish in every respect. The high reputation which has been acquired by the comparatively small quantities packed in California during the past five or six years, and the excellent prices which they have commanded, argue well for the success of an extensive business.

THE LATE EPIDEMIC OF SMALLPOX IN THE UNITED STATES.

By Dr. JAMES NEVINS HYDE,
RUSH MEDICAL COLLEGE.

THE adaptability of man to his environment is one of many generous provisions for his welfare. But it is a provision with conditions. The adaptation once secure, even a temporary failure of complete adjustment to the environment may be perilous.

The commercial travelers of all countries are accounted, on the whole, as of a healthy class; they breathe all airs, they drink all waters, they consume all foods with impunity. They are rarely adjusted to a single environment for any length of time. The farmer, on the other hand, long habituated to his narrow circle of surroundings, would often become seriously ill if for a time he should leave his farm and village to breathe the air and drink the water and consume the food that are familiars of the traveling salesman who would sell a lightning-rod for the protection of the farmhouse.

This adaptability extends to a surprising degree toward the limit of endurance of toxic agencies. The farmer whose case has been supposed may year after year drink with impunity the water from a well contaminated with germs that would promptly induce typhoid fever in one wholly unaccustomed to a daily dosage of the poison. But the same farmer may lose his immunity if for any length of time he removes to another residence and afterward, returning to his own place, makes use of the contaminated water to which he was once habituated.

The greatest peril from loss of adaptation to environment lies in the changes wrought by the sudden removal of a man from his country home, or even from a less salubrious city residence, to a situation where men are massed together in considerable number. Here a new and complex problem is presented. If every man of those thus suddenly congregated had recently surrendered his adaptation to a special environment, the chances of thus begetting disease are enormously multiplied. Such a condition is presented in prisons, hospitals, great fairs (such as those at Nijni-Novgorod, Chicago and Paris), and especially in the camps of soldiers. The camp as a focus of disease is more potent than all others; for one reason, among others, that even though previously subjected to selection by physical examination, and supposedly under the direction of sanitarians, the recruits are not free to select for

themselves their sleeping places, food and clothing, but are at many points under subjection. Not only are they densely massed together, but they are not adapted to the new environment, even after they become veterans, who may be classed as respects immunity with the commercial traveler and the 'globe-trotter.'

War and pestilence are twin brothers, but they do not always work side by side. Often pestilence follows war; more rarely they reap their dreadful harvest on the same day. The word 'pestilence' should be understood to include not merely the grave plagues that have decimated the human race, but the less severe epidemics of disease which have spread over large areas of space and affected to a less extent great numbers of the human family. Even thus, however, in comparison, the deadliness of war is far surpassed by its grim camp-follower. Where the one slays its thousands, the other destroys its ten thousands.

In this country, the epidemic visitations following war have been both mitigated and severe. We fought Great Britain in the Revolution, and soon after were afflicted with maladies some of which had not before tormented our people. Soon after 1780 the daily papers of Boston, New York and Philadelphia were filled with advertisements of remedies for the itch, a malady which had never before so multiplied on our soil, water being abundant, soap cheap and the habits of our forefathers cleanly. The War of 1812 was chiefly naval and its aftermath of disease insignificant, for the reason that of all afloat the American war vessel has ever been the most scrupulously clean. But the Mexican War was followed by an epidemic of cholera of severe grade; and the late Civil War was the precursor of a succession of typho-malarial fevers that were previously almost unknown save in certain special localities and to physicians there resident. In a similar way the plague followed the Saracen armies under Mahomet in 622; syphilis spread through Europe after the campaign of the dissolute Frenchmen who followed to Italy the standard of Charles VIII.; and the English paid a price for the crushing of the last of the Plantagenets on Bosworth field in the epidemic of 'sweating sickness' that ensued.

Our late war with Spain was followed by an epidemic disorder which spread extensively throughout the United States, and which has attracted but little attention from our public economists, for the reason that it has been suggested to few to see the results in a comprehensive survey of the broad area involved in the extension of the disease. The malady spread from the eastern and southern borders of the United States to the Middle West, and thence in regular progression to the Pacific Slope, including in its progress not merely the States where there are efficient health boards, possessing ample powers and trained officials, operating with modern methods, such as New York, Pennsylvania, Ohio and Illinois; but also the as yet partially

settled districts of the further West as far as Idaho, Oregon and California. The sweep of the malady has included individuals of the white race, the Indians and the negroes, the well-to-do and the poor, the filthy and the cleanly, people of all sorts and conditions. If the results had been in any considerable proportion grave, the entire country would have been alarmed, and the attention of all classes concentrated with a profound interest upon the earliest invasion and progress of the disease in the several localities where it spread. But, fortunately, the results were mild, so mild, indeed, that the nature of the epidemic, certainly at first, was misunderstood in almost all the places where its victims were discovered. Medical men, well trained in their profession, in many cases could not recognize the nature of the malady by reason of the special features it now for the first time presented. Some physicians, even after demonstration by experts of the character of the symptoms before their eyes, refused to accept the inevitable conclusions. Though obviously a contagious disease and one spreading in epidemic form in an astonishingly large number of villages and towns, East and West, the victims of the disease, because of the very general misapprehension respecting its nature, were permitted free access to those not affected. In many such centers of population, persons betraying all the external evidences of the disease attended churches, schools and theaters; delivered milk, groceries and other provisions at the houses of their customers; officiated in public stations; and even slept in beds occupied by other non-infected members of the same family. A study of the special character of this epidemic possesses interest, because, as a matter of fact, the malady was smallpox.

The history of smallpox in classical career has been studied with a patient faithfulness and with an attention to every detail that is set forth fully in most of the text-books. Few trained physicians are ignorant of the essential facts thus collated. In the late epidemic visiting this country, confusion in many cases arose from the total failure of the symptoms of the disease to correspond with the classical types previously portrayed in the books and encountered in practice. Almost all the histories of smallpox in the past have been descriptive of epidemics that spread among a people either previously unprotected from the disease by modern methods, or through the medium of individuals not so protected. It might, however, have been expected that an epidemic of disease occurring during the last century and another at the beginning of the present, operating on a different soil and under different conditions, would exhibit differences in type.

That smallpox may be so modified as to be stripped of every one of its formidable features has long been known. The so-called *variola sine variolis* (smallpox without pocks) is not a fiction of the schools, but a fact of experience. In these instances, after a day or two in

which there may be slight sensations of chilliness and possibly moderate fever, the disease actually not preventing the patient from attending to his or her usual vocation, the end is reached, and without the occurrence of eruptive symptoms. These cases are sufficiently common, and the proof of the reality of the variolous process in one class, where the patient afterward is not capable of receiving disease in an epidemic, is substantiated by the proofs furnished by another class of cases, in which, for example, a pregnant woman, having suffered no more than in the instance cited, later brings into the world a child covered with unmistakable symptoms of the disease.

From the extreme of benignancy illustrated in such a group of cases to another in which symptoms are exhibited of a severity just short of the pronounced features of classical smallpox, there is every gradation and not a few excursions to the one side or the other of oddity and apparent caprice. In the late epidemic, physicians were often at sea respecting the nature of the disease, because, perhaps, after a regular onset of classical and threatening symptoms, there followed an almost absurd abortion of the morbid process, which in twenty-four hours or more lost every menacing feature; or the eruptive phenomena failed to develop the characteristic fluting or puckering of the vesico-pustules known technically as 'umbilication'; or the peculiar odor of the disease was lacking; or the mouth failed to exhibit symptoms; or the progression of the eruptive phenomena from point to point of the body-surface was not according to rule.

The question of the influence of vaccination upon the victims of the epidemic and others aroused special interest. It was claimed in many of the localities where the disease prevailed that the vaccinated and unvaccinated suffered alike; and hence that vaccination did not protect. It was further claimed that in some cases vaccination had been effective in those who were convalescent from the new disease. And thus blunders innumerable complicated the question, the answer to which was of the highest moment to the welfare of the commonwealth. The disease was variously called 'Cuban itch,' 'Porto Rico scratches,' 'Cuban measles,' 'chicken-pox,' 'Porto Rican chicken-pox,' 'Spanish measels,' etc. These popular names constituted the jargon of the ignorant. There are no maladies in Cuba, Porto Rico or Spain recognized by any such terms or others like them.

Greed is among the most potent of human motives, and it must be admitted that in the presence of the late epidemic, among those who were ignorant of its nature, there were to be found others who preferred to close their eyes to the facts. Merchants did not care to suffer the paralysis of their local trade which usually is wrought by the panic that flees before a pestilence. Editors of papers in the smaller towns were unwilling to spread the news to their immediate rivals in the

adjacent county that their readers were victims of a disease which should be fought by quarantine. School boards did not care to dislocate the machinery of their system. Manufacturers pleaded for the families likely to be ruined if their works were shut down. In the minds of many there were a shame and a disgrace associated with the fact that they were singled out for the explosions of the pest; and there was some reason for this. Hence, in a considerable proportion of cases, the officers of local government, the large employers of labor, school superintendents and others refused to accept the facts, basing their belief on the evident mildness of the malady, and often upon the remarkable result that after a fortnight or more of the prevalence of the disease in their community there had been either no fatal results or so few that in several hundreds of cases the disproportionate mortality was so small as to disprove the accusation that smallpox was prevalent.

And yet smallpox indeed it was; mitigated, it is true, but still capable of awaking to a frightful activity in a favorable field and at an opportune moment. For it is among the facts established by a bitter experience that the mildest and most modified type of the disease, varioloid, for example, of insignificant features, may be the source of one of those epidemics of smallpox which rival in their mortality the most direful of the scourges that have afflicted the race.

Why was the late epidemic the mildest in its type and consequences of any of the same nature that have preceded it? Why were its features so masked that even physicians of experience failed to recognize them? Why was the resulting mortality so slight that the malady awakened little dread in the communities which it invaded, the people, made familiar by contact with its manifestations, failing to exhibit the horror which has usually been excited by its presence?

The answer is inwrought with the solution of some of the tremendous problems of the future of the human race. If devastating plagues cannot be wholly obliterated, can they be so modified by scientific methods that they are gradually converted into trifling ailments, productive of minimized danger and followed by trifling sequels? The culture-tubes and culture-plates of our bacteriological laboratories have spelled out the answer in sterilized media. The potency of almost all germs may be first gradually weakened and later annihilated by cultivation in special soils. Fraenkel has demonstrated that an enduring decrease, even a complete and irrevocable loss of virulence, has been produced by artificial cultivation of most of the different species of pathogenic bacteria, among which may be cited as conspicuous examples the germs of swine-erysipelas, of symptomatic anthrax and of pneumonia. Thus a minute organism, descended from a death-dealing source, may

become in the culture-tubes of the experimenter as harmless as those found in an ordinary infusion of hay, such as the *bacillus subtilis*. Even thus the wild boar is proven the ancestor of the domestic hog, and the wild-cat the remote progenitor of the Angora kitten.

Even scarlet fever, under the impulse of some such causes as those under discussion, has evolved a 'new type,' which has been set forth by a competent health officer, Dr. William Robertson, of Leith. He reports that compulsory notification has not only lowered the mortality of scarlet fever, but actually modified its type, so much so that it is now difficult to tell when one has or has not to deal with the suspected disorder. On every side one hears it repeated that epidemics are now characterized by a want of symptoms and signs. The bright red rash is seldom seen, and when there is a rash it disappears before the arrival of the medical attendant. If one looks for throat-signs, they, too, may have been transitory. The symptoms of onset are so slight that even an anxious parent takes no notice of a passing indisposition.

These are the evidences, oftentimes somewhat vague, but again both significant and unmistakable, that the dream of the scientist is to have its realization in the future. Few believe that the great pests of the human family will be suddenly jugulated or annihilated. The gradual extinction of each by modification, by attenuation of virus, and by elimination of grave symptoms, is the aim of scientific medicine, and its disciples can thank God and take courage for the fruits of their labor, realized each year in larger measure and with fuller promise.

The germ of all epidemics of smallpox is one, but the soils on which it has grown are many. The culture-tubes and culture-plates on which it has been propagated until it has lost much of its potency and even many of its features are the bodies of the men and women of the last quarter of the nineteenth and the early part of the twentieth centuries.

The late epidemic of smallpox in the United States was the legitimate fruit of the Spanish-American War, and the popular terms by which it was designated among the common people, like almost all folk-words, contained a kernel of truth. Cuba and Porto Rico, before our armies descended upon their shores, were like the Philippine Islands, very abiding-places and citadels of smallpox. Our returning troops brought back with them the effective elements which lighted up the late epidemic in the United States. But the germ-carriers in this instance were our own previously vaccinated soldiers. The germ was attenuated in its potency at the outset. When it gathered to itself the added power by which it was enabled to spread from community to community, its extension was not through a population virgin of protection by previous vaccination, but for the most part constituted either of the vaccinated or of the children of the vaccinated.

Unvaccinated but yet 'children of the vaccinated'—is any degree of immunity conferred by inheritance? However difficult of exact demonstration, the affirmative must be accepted not merely as a logical sequence of the experiments in the laboratory to which reference has been made, but by certain clinical phenomena of striking importance. For example, it is well known that among some of the immigrants touching our shores for the first time, who come from countries where the mosquito is not found, notably from English homes, the ravages produced in midsummer, when women and children especially are lodged in cheap boarding-houses, with windows unprotected by screens, the results of the attacks of the American insect upon their exposed skins are of a grade of severity unparalleled among natives of our soil. Generations of Americans have succeeded in establishing a partial immunity by the mere succession of these accidents in a long series of summers; so that while they may, and actually do, suffer from mosquito bites, the effects are far milder and without any proportion to those experienced by the immigrant. A striking illustration of this fact is recorded in the history of the Revolutionary War, when in the midst of their first summer on this soil the mercenary troops from Hesse-Darmstadt and Hesse-Cassel were so savagely attacked on their march from Trenton that whole platoons of troops were unable to distinguish objects through their swollen eye-lids, and were thus rendered wholly unfit for duty. Looking at the obverse of this proposition, every student of public hygiene is aware of the fact that truly formidable ravages of smallpox occur in epidemics attacking virgin populations, as, for example, islanders long unvisited by Europeans, where neither the individuals themselves nor their ancestors for generations have enjoyed the immunizing protection of vaccination. In these cases it is often not merely a decimation which results, but it may be a destruction of more than half of the entire population. In a few isolated instances almost every individual of a tribe or village has been cut off. Not the sins alone of the fathers but some of their safeguards are visited upon the children. The clean living that drove away leprosy from English soil and that so widely substituted the gout for the 'King's evil,' has tinctured the blood of the children of the men who fought at Naseby and learned a lesson in humanity from Howard.

It will be seen that the whole question pivots upon vaccination. It is necessary to look critically upon this means of securing immunity, for the procedure is again under the searchlight.

All said and done, vaccination is an invaluable means of securing immunity against smallpox, but it is not a perfect means. What artificial conquests of man are rounded to the perfection-point? Every one knows that the finest double-screw steel vessel that steams across the Atlantic can be crushed by a single blow of the arm of the sea if

the gale be sufficiently furious and the billows sufficiently huge. As it is necessary to admit that even one attack of smallpox does not confer absolute immunity against a second, seeing that some men have had two and even more of such attacks in a lifetime, equally must it be admitted that vaccinated persons, and even many times revaccinated persons, have had attacks of smallpox. In ordinary seasons when smallpox is not prevalent a larger protection is conferred by vaccination than that conferred by the lightning-rod upon the dweller beneath the roof above which it rises. But in seasons of epidemic influence, even though the epidemic be as mild as that which furnishes the theme of this paper, such an influence is appreciable and in many cases highly effective. At these times those who previously were incapable of being vaccinated (even the vaccini culturists occasionally find heifers which cannot be made to serve as vaccinifers) are inoculated with ease; at such times also vaccination can be made effective even after the onset of unmistakable symptoms of smallpox; at such times also even those who have had smallpox can be vaccinated, and that after the recent establishment of convalescence. The ardent advocates of the position that the mild epidemic through which this country has just passed was not one of smallpox pointed with what seemed to them convincing force to the fact that they had successfully vaccinated the victims of the disease immediately after recovery. But the argument was without force. The skin of a person convalescent from smallpox is in an exceedingly irritable state and readily is excited to the production of local symptoms at the point where the needle of the vaccinator has been at play. It has to be borne in mind that the actual introduction of a disease by inoculation is a far more rigid test than mere exposure to a volatile poison, the kind of exposure through which, as a rule, smallpox is acquired. What physician, for example, would dare to inoculate a patient with the virus of smallpox after the most classically perfect vaccination? He would be held criminally liable for the result if, as might happen, in this way he should disseminate the disease throughout the community in which he lived.

But the spurious results cited of vaccination of convalescents from modified smallpox prove nothing. Even highly typical results would not disprove the fact of a previous attack of modified or unmodified smallpox. It has been shown that both the vaccination process and the variolous process may pursue their career at one and the same time in the same body. But Dr. Mosely, of Kentucky, put the question to a decisive test last year when he vaccinated three negroes, each convalescent from smallpox, immediately on his release from quarantine. Each subsequently exhibited classical results of successful vaccination in due time and course.

Respecting the enormous value of vaccination to the human race, it

would seem scarcely necessary to appeal to statistics at this late hour of the scientific day. But surely so long as we have the poor with us, we shall have with them a class of men whose minds are so curiously constituted that they will select for study the nether side of the social fabric, the weakness of the best of governments, and the minor defects in the character of the world's heroes.

Even as late as the month of April in the first year of the new century one of the largest and most widely read of the daily papers of the country published over the name of a well-known anti-vaccinationist a statement apparently made in good faith to the effect that vaccination counted more victims than smallpox, and that the practice was a relic of barbarism, asking that a halt be called upon the passage of compulsory laws looking to the protection of the people by any such measures. These singular protests against the operation of the most beneficent of life-saving devices will probably be repeated so long as there is a law on any statute book. Their starveling and distorted figures, garnered from the refuse heaps of mortality, must ever and again furnish forth the tables on which these purblind reasoners rely. They close their eyes to the latest signal victory of science in this field. The Island of Porto Rico, according to the report of Surgeon-General Hoff, in the year 1896 harbored no fewer than three thousand cases of smallpox. Imagine a State of the Union of similar size exposed to such an extent to the ravages of the disease! After the establishment, however, of a government vaccine-farm, "eight hundred thousand natives were vaccinated, at a cost of about four cents for each individual, with the result that by October, 1899, no case of smallpox was known either to the military or civil authorities anywhere in the island." This was a fine illustration of the carrying of 'the white man's burden.' Porto Rico bombarded us with a filth-germ and in revenge we made her clean!

In the year 1867 vaccination was made compulsory for school children in the city of Chicago, and for twenty years after there was practical immunity from smallpox for this important class of the population; while the police of the same city, exposed to every form of infectious disease in their surveillance of its several districts, since vaccination was made compulsory also for them, have never developed a case of the disease.

Dr. Buchanan, medical officer of the local government board (England), in 1881 prepared a table of comparative smallpox death rates among Londoners, vaccinated and unvaccinated respectively, for the fifty-two weeks ending May 29, 1881, calculating that the vaccinated persons of all ages living in London, in the twelve months concerned, were 3,620,000, and the unvaccinated of all ages 190,000 in number. This table reads:

Death rate of people of subjoined ages	Per million of each age of the vaccinated class.	Per million of each age of the unvaccinated class.
All ages	90	3,350
Under twenty years	61	4,520
Under five years	40½	5,950

Statistics of this sort might be piled mountains high; but they mean nothing and they count for nothing with the prejudiced. It is well to remember at times that any agency and influence operating at any one moment upon large masses of human beings of both sexes and of all ages has to bear its percentage of damage and death. The killed on the day of the passing of the funeral cortège of Queen Victoria, the fatality attending ocean and railway travel, even the victims of the awful fire-tragedies lately occurring in Paris and New York, which shocked every reader of the public press, have not deterred men and women of ordinary common sense from going to fairs, sleeping in hotels, or crossing the continent by rail or the ocean steamer. Vaccination of every member of any community, including men, women and, in particular, infants will, without any question, be followed by untoward results in a proportion of cases. The mere statistics of common accidents and ordinary disease account for a large part of the list in the relatively slender catalogue of vaccination accidents. Men, women and children perish annually from the stings of bees, from the bites of flies, from the prick of a pin, and from the accidental impaction of a bit of food in the larynx. Lately a physician reported a disease *not* due to vaccination. An infant was brought by appointment to his office in order to be inoculated, but the physician chanced to be called away from the city, and the date of the trifling operation was postponed for a week. In that week the child developed symptoms of syphilis, which would probably have been laid to the account of the vaccination if the latter had been performed.

It has been said that if the modern tourist could be transported to the streets of London in the eighteenth century, before the general adoption of the practice of vaccination, he would be immensely astonished, not so much by the quaintness of the dress and the speech of the people, by the aspect of their shops, and by the odd-looking vehicles on their streets, as by the extraordinary number of pock-marked faces he would encounter on every hand. Even as early as the year 1778, the officers of foreign troops on American soil wrote back to their countrymen in the old world that the American women were surpassingly beautiful and were very 'seldom pock-marked.' Macaulay, describing the distress in London in 1694, wrote as follows: "That disease over which science has since achieved a succession of glorious and beneficent victories was then the most terrible of all the ministers

of death. The havoc of the plague had been more rapid; but the plague had visited our shores only once or twice within living memory, and the smallpox was always present, filling the churchyards with corpses, tormenting with constant fears all whom it had not yet stricken, leaving on those whose lives it spared the hideous traces of its power, turning the babe into a changeling at which the mother shuddered, and making the eyes and cheeks of the betrothed maid objects of horror to the lover."

At last our English brethren have learned the lesson and learned it well. They have had bitter experience of the devastation which smallpox is capable of working among their kindred, whether in the hovel or in the palace. They have mourned the loss of a gracious sovereign smitten with the pestilence on the very throne of their kingdom. While we may not wish to follow them in all matters, they have set us a worthy example in the patience with which they have buttressed their bulwarks of immunity. The germs of this pestilence are powerless against the army of their humble villagers and peasantry, ranks upon ranks of whom bear upon the arms of each no fewer than four, and often as many as six and eight, simultaneously produced scars of successful inoculation of cow-pox. Vaccination should be the seal on the passport of entrance to the public schools, to the voters' booth, to the box of the juryman, and to every position of duty, privilege, profit or honor in the gift of either the State or the Nation.

FOOD AND LAND TENURE.*

By EDWARD ATKINSON.

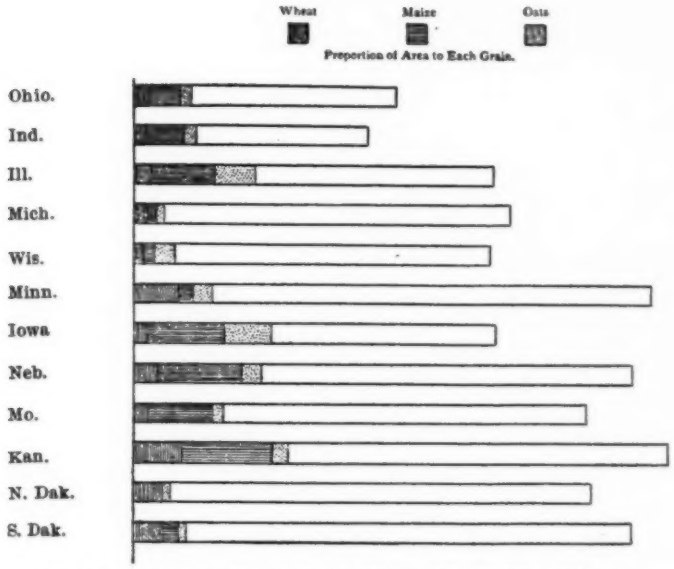
THE conditions of Europe in the present year compel attention to the food supply of what is called the civilized world. The principal supply of grain exported and a large part of the supply of meat are derived from the central United States, in the northern section of the Mississippi Valley.

The area of the twelve States of the northern Mississippi Valley, on which main dependence is placed, is given in the subsequent table; also the proportion of each State which is now devoted to the crops of Indian corn or maize, wheat and oats, which are the chief dependence for the grain supply of man and beast; rye, barley and buckwheat being of minor importance. In another table the proportion of the area of each State which is devoted to each of the three principal grains is indicated graphically.

	Land, Square Mile.	Wheat.	Area Devoted to Maize.	Oats.
Ohio	40,760	2,220	4,514	1,659
Indiana	35,910	1,890	6,299	2,144
Illinois	56,000	2,161	11,156	5,495
Michigan	57,430	1,906	1,688	1,434
Wisconsin	54,450	1,327	1,936	3,026
Minnesota	79,205	7,665	1,505	2,598
Iowa	55,475	2,183	12,577	6,001
Nebraska	76,840	3,229	12,646	2,708
Missouri	48,735	2,356	10,084	1,408
Kansas	81,700	7,282	13,476	2,129
North Dakota	70,195	4,202	37	956
South Dakota	76,850	4,563	1,876	920
	753,550	40,984	77,794	30,478

By far the larger proportion of all these States is arable land, portions of the western section being for the present uncertain in their product, because of semi-arid conditions. Ere long, however, these sections may become the most productive, irrigation on a national scale being under way.

* Read at the meeting of the British Association for the Advancement of Science, Glasgow, September 11-19.



Grain growing States of the Northern Mississippi Valley.

Total Area of Land of the United States Devoted to Maize (Indian Corn), Wheat and Oats. Crop of 1900.

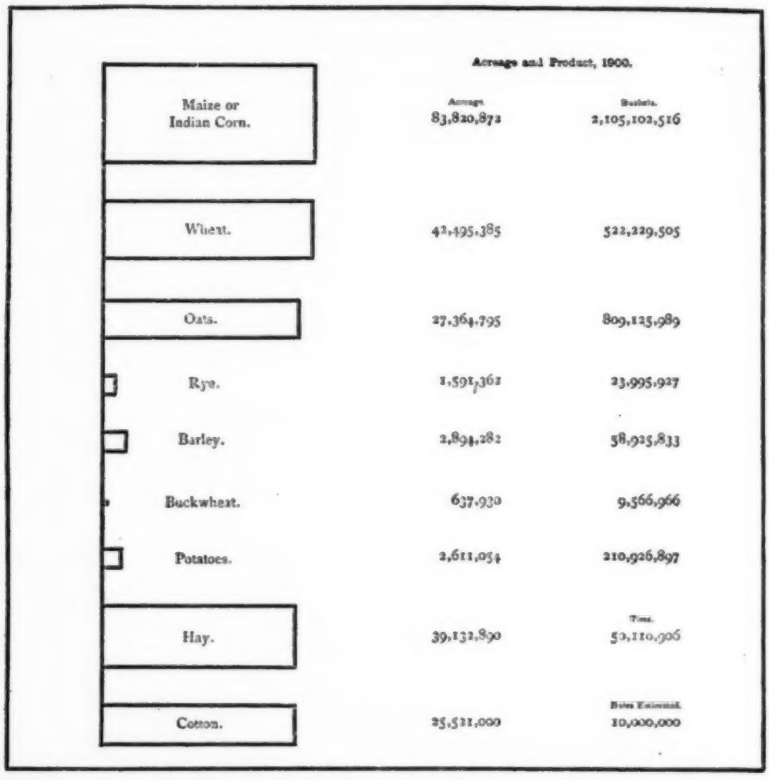
	Square Miles. All States.	12 Mississippi Valley States.	All other States.	Crop Bushels.
Maize	125,500	77,794	47,706	2,105,102,516
Wheat	66,400	40,984	25,416	522,229,505
Oats	42,754	30,478	12,276	809,125,989
Total	234,654	149,256	85,398	3,436,458,010

Crop of 1900.

	Acreage.	Product.	Average per Acre.
Ohio	1,420,646	8,523,876	The crop of 1900 was below the average per acre of the last ten years. The crop of 1898 was 675,148,705 bushels at 15.3 bushels per acre. The crop of 1901 is officially estimated at 704,000,000 bushels and will probably be more.
Indiana	1,209,755	6,411,702	
Illinois	1,383,230	17,982,068	
Michigan	1,219,969	9,271,764	
Wisconsin	849,458	13,166,599	
Minnesota	4,905,643	51,509,252	
Iowa	1,397,322	21,798,223	
Nebraska	2,066,825	24,801,900	
Missouri	1,507,737	18,846,713	
Kansas	4,660,376	82,488,655	
North Dakota	2,689,023	13,176,213	
South Dakota	2,920,244	20,149,684	
	26,230,234	288,126,649	
All other States	16,265,151	234,102,856	
	42,495,385	522,229,505	

In 1900 the product of the United States, 522,229,505, was substantially 20 per cent. of world's product of 2,586,025,000 bushels. The land devoted to wheat was 2.3 per cent. of the total area, omitting Alaska.

12.29 bushels per acre.



The area of the United States (omitting Alaska), a little less than 3,000,000 square miles, is represented by the outer square. The proportion of land cultivated in all the principal crops that count for much in acreage is indicated by the smaller areas computed on the same scale. The total area in the above crops in the year 1900 numbered 353,275 square miles, or about twelve per cent. of the total area.

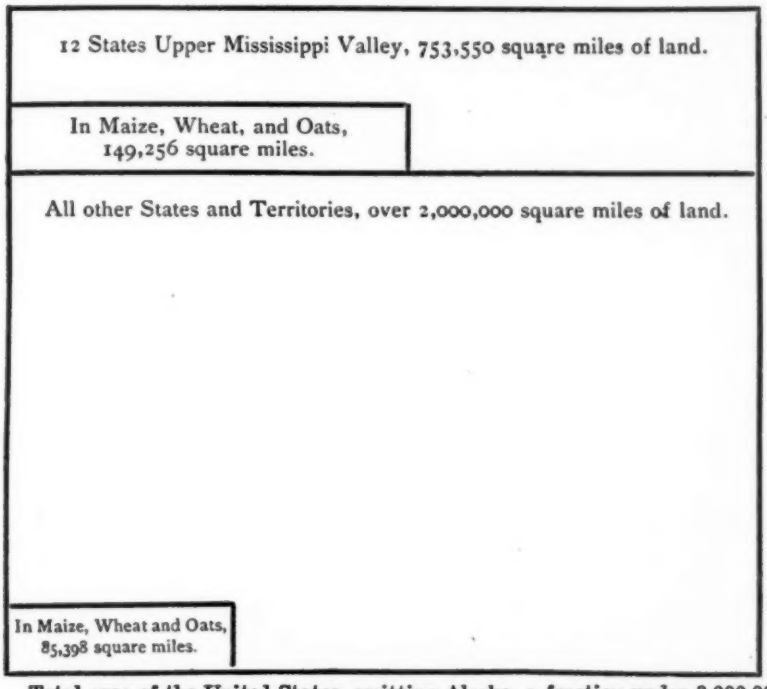
JULY, 1900. COMPUTED BY EDWARD ATKINSON, BOSTON, MASS.

The proportion of land in the twelve Mississippi Valley States listed which is devoted to wheat is five and a half per cent. of their land area.

The change which has come over this section can be put before the imagination in no better way than for the writer to state that he himself witnessed and clearly remembers the war dance of the Blackhawk Indians on Boston Common, when the chiefs were sent around the country by the Government after they had been subdued in the last great Indian war, which occurred in central Illinois, at the very heart of the section with which we are dealing, and very near the present center of population of the country.

The question arises: What is the basis or fundamental principle underlying the change from occupation by the wild or 'blanket'

Indians, as they are called in our country, to the present system of intensive agriculture in a period of less than two generations? I venture to indicate freedom of restriction in custom or law in the purchase and sale and mortgaging of lands as the basis of this great change. The underlying principle, now being rapidly developed, is the gradual change from working land as a mine, subject to exhaustion, and using it as a tool or instrument of production, responding in its product to


12 States Upper Mississippi Valley, 753,550 square miles of land.
In Maize, Wheat, and Oats, 149,256 square miles.
All other States and Territories, over 2,000,000 square miles of land.
In Maize, Wheat and Oats, 85,398 square miles.

Total area of the United States, omitting Alaska, a fraction under 3,000,000 square miles. Area under cultivation in maize, wheat and oats in 1900, 234,654 square miles, or a fraction under eight per cent. of the area of land and inland waters. The latter should be included in the food-producing area.

the measure of mental energy and mechanical aptitude applied to its use. These factors are generated in the free common schools now being supplemented by the addition of manual training schools in all the principal towns and cities.

Dealing in a broad and general way, all are aware that the titles to the vaster portion of the land in these States are derived from the government, mainly since the lay-out of land in sections of six hundred and forty (640) acres each, and quarter sections of one hundred and sixty (160) acres. This land has been disposed of in various ways—to railroad companies as bounties to aid in the construction of railways, and to individual purchasers and settlers under various laws. The

lands granted to private individuals have been, since 1860, usually in small tracts, varying from eighty (80) to one thousand (1,000) acres, the greater share being in tracts known as quarter sections of one hundred and sixty (160) acres. This is the one always required under the Homestead and preemption laws. The lands of railroads were originally granted to them in large tracts. Some of it has been disposed of by them in large tracts to wealthy corporations and individuals and by them converted to vast farms, known usually as 'bonanza' farms. The balance has been sold or is in the process of sale, in smaller tracts on long-time credit to poor settlers. The usual method of sale is one tenth cash and the balance in nine annual payments with interest. The ordinary sale of this railroad land is a tract of one hundred and sixty (160) acres, the one on which the poor settler, as a rule, begins his career on the frontier.

The first settlement of the frontier, as now described, is accompanied with many transfers of land title, owing to the facilities of such transfer and by reason of the benefits that all parties can find in the same. Many who have acquired land under the Homestead law sell it to their neighbors or to a newcomer with ready money. They then take up a new farm under the preemption law, and use the money received for the sale of the first farm to improve the second. The divisions of the bonanza farm, the land of which is usually purchased from the railroads, combined with the results of those transferred among the original settlers, give to the farmer on the frontier an average size of from two hundred and forty (240) to three hundred and twenty (320) acres, the largest containing thousands of acres and the smallest from twenty (20) to forty (40) acres.

When first settled, these large and small farms in the grain-growing sections are always cultivated on an extensive system, largely in grain. The original occupants, whether of large or small farms, turned over the sod and planted their grain with the application of very hard labor and without fertilizers and, as a rule, without any very general comprehension of the art of agriculture. This was the necessity of the case, and it has been and is still a success under the conditions of the frontier. Under these conditions a vast body of pioneers have become prosperous, some of them attaining large wealth, and with their wealth buying out their less successful neighbors and adding to the area of the great farms. That phase has nearly passed by in the great Mississippi Valley and in the States named. With the passage of years, in every part of these twelve States, this extensive system of cultivation comes to an end and the intensive system of working the land in various crops takes its place. With this change the large bonanza farms are broken up and the smaller farm becomes the rule. This change is a progressive one,

as can be seen by the average size of farms in the twelve States. In 1890, this was 86 acres in Michigan, 93 in Ohio, 103 in Indiana, 115 in Wisconsin, 127 in Illinois, 129 in Missouri, 151 in Iowa, 160 in Minnesota, 181 in Kansas, 190 in Nebraska, 227 in South Dakota and 277 in North Dakota. Ohio and Michigan have been the longest settled, while the two Dakotas are not yet wholly occupied by farmers.

On the frontier, the wild land from the government has a value of $1.25 per acre. The railroad grant lands have been usually purchased by farmers at from $4 to $7 per acre and are now being sold at these figures. The average value of farms with improvements in the old settled States, such as Ohio, is not far from $50 per acre. The difference measures the improvements made to the land. To open up new land and make these improvements requires capital. The original settlers, being without capital, were under the necessity of securing credit, either from the railroad companies from whom they purchased the land or from money lenders; hence there grew up in these western States a very extensive system of borrowing on mortgages, beneficial both to borrower and lender, until the speculative mortgage companies promoted the taking up of great areas of land in the semi-arid regions, negotiating mortgages thereon, and thus brought disaster to many lenders, culminating in bankruptcy of many mortgage companies.

The average term of mortgages made for land improvements, as above outlined, has been in the past from three to nine years, and that period of time has usually, except in the semi-arid lands, sufficed to enable the settlers to pay off their debts and to acquire valuable farms from their neighbors.

These figures are sustained by the judgment of the experts now occupied in compiling the census of the year 1900, in which the departments of agriculture and of wealth, debt and taxation are under the supervision of the most competent man in the United States, Mr. L. G. Powers.

It will be plain to any Englishman that unless this land had been free land, bought, sold and conveyed with the least amount of expense and difficulty, and free of any conditions as to the kind of crop to be planted or the disposal of the product, no such great economic revolution could have occurred. Yet the conveyance of land is now being made more simple than ever before by the adoption, in State after State, of a reform which we owe to our intelligent and progressive kindred in Australasia, the registry of titles known as the Torrens System, in place of the registry of deeds. Under this system conveyance of a title to land under absolutely safe conditions has become as simple and as easy as an assignment of a note of hand or a share of stock.

Under these conditions in these and other States 5,700,000 farmers are now working land either as owners or tenants, the only limit in recent years to a further expansion of crops having been the lack of farm laborers. At the present time (July 9th) farm laborers are in most urgent demand to harvest the great crop of wheat, without any sufficient supply.

During the last decade there has been in these States a small lessening in the average area of the farm, coupled with a moderate increase in the number of tenants. The owners have increased faster than the agricultural population, and the greater increase in the number of tenants has been recruited from former farm laborers or from emigrants. Landlordism in the sense of ownership of very large areas to be worked permanently by tenants, covers a very small part of this whole area. It is inconsistent with the whole spirit of the people and will never assume any great importance.

In the new States, such as Minnesota and the Dakotas, it is still possible to buy cheap land from the railroad, from large timber companies and from the State and general government, and to repeat the old process of a poor man acquiring a good farm free from debt in from three to ten years by the aid of a small mortgage loan or the credit of the land companies. In the older settled communities, with land worth on an average from $40 to $50 per acre and in many cases selling for $100 per acre, the road to farm ownership for the poor man is somewhat different. He must as a laborer have acquired money enough to become a farm tenant and as a tenant have obtained sufficient capital to make a reasonable payment on the purchase price of the farm. This gradual rise of a farm laborer to farm ownership through farm tenancy is being witnessed all over the States to which I have referred. Mortgage assists, as on the frontier, in helping the men with small capital to control farms worth more than their resources over and above their liabilities. These men, rising in the older settled States to farm ownership, through farm tenancy and by the aid of mortgage loans, in a large measure succeed in paying off their debts as does the settler on the frontier. With a large debt due on the more valuable farms, it may require a longer time, but the end is reasonably sure with those of any business sagacity.

Another class of farm tenants in America is composed of the children of the farm owners who cultivate their fathers' lands as tenants until they succeed them as owners. No farm laborer who is not a good farmer succeeds in rising, and the sons of wealthy land owners, without good management, often lose all their inherited wealth. Freedom to buy and sell and manage land kills off the incompetent, and gives the field to the competent, be he poor or rich. This freedom of land sales prevents the tenant or owner

from adopting methods formerly described by Governor Wise of Virginia, as that of slavery, when he said that 'the white men skinned the nigger and the nigger skinned the land.' There is an element of skinning in every system relating to land not born of perfect freedom. Perfect freedom in the purchase and rental of American land leads to constant improvement.

Under the freedom of sale which prevails in the United States, with the facility of mortgage loans which permits the poor man to use the capital of the rich to secure for himself a farm, there will always be a large mortgage debt in the rural sections of the United States. That debt marks, as a rule, the upward movement of the poor laborer on the road of farm ownership. One class of men incur debt for land purchased or for improvements, and pay off the same, and as they retire in old age another and younger set repeat the process of rising to independence by the same road. The relative number of those who have attained their goal and of those on the way may be seen by the following figures:

Of the farms in the twelve States named, about sixty to sixty-five per cent. are now free from mortgage debt, and thirty-five to forty per cent. are mortgaged. The debt on the mortgaged farms does not exceed thirty-five per cent. of their value, and the total mortgage debt of the States is not in excess of about twelve to fifteen per cent. of the whole farm value.

Under these conditions the area of land devoted to the several grain crops diminishes in ratio to that given to other crops, varied farming taking the place of the all-wheat or all-corn system. But by the introduction of intensive farming there is a steady improvement and increase in the quantity and the quality of the crops derived from a given area of soil. The wheat needed for home use will keep even with population for many years without any increase in area.

The most potent agency in this revolution in agriculture may be but little known in Europe, especially in England. I refer to the so-called Agricultural Experiment Stations, which have grown in a rather singular manner, of which no very definite record has yet been given. The general government appropriates annually $720,000, and the State governments $440,000, more or less, in addition, to be expended by the Agricultural Experiment Stations, under the general supervision of a special department in the Department of Agriculture, of which Professor A. C. True is now the director. But the general government has no very definite control over the expenditure of this money. The stations are established by the several States. They are now thirty-six in number—one in nearly every State; two or three in some of them. Each one is under the direction of a trained student of the science of dealing with land as an instrument or tool of produc-

tion. The employees are all thoroughbred experts, graduates of universities, colleges or technical schools. A more devoted set of men cannot be found in the whole country. Their influence is raising the standard of farming in almost every State. One of the great railway promoters in the Northwest long since realized the importance of this matter, and in order to promote the interests of his railroad he made arrangements with every town throughout the great State near the line to send two men every year to the capital, where the Agricultural College and Experiment Station were situated. He gave them a free pass, liberty to remain four days, the State giving them a banquet—the only condition being that one day out of the four should be devoted to the study of the work of the Agricultural Experiment Station; and for a number of years one thousand (1,000) to fifteeen hundred (1,500) men enjoyed this benefit every year.

Each Experiment Station devotes itself to the special conditions of the State in which it is placed. For instance, in Minnesota the whole standard of wheat cultivation and of dairy product has been raised to a very high point. In Michigan the market value of a large product of butter has been raised to a more profitable point by improvement in stock, in the establishment of creameries, and in other ways. The application of the bacterium of June butter in the creameries has become common.

Professor Kohn, who made this discovery at the Columbian Exhibition in Chicago, in 1893, has established a bacterium factory which, at the last advices known to me, supplied one hundred and fifty (150) creameries with the ferment.

In Kansas attention has been given to the improvement in the quality of maize or Indian corn. The ordinary maize is deficient in the nitrogen or protein elements as compared to the starch and fats. Varieties have been bred, bringing maize even with wheat in the protein element, which may end in making maize as complete a food as either wheat or oatmeal.

In the South the greatest attention is given to renovating plants of the leguminous type—beans, peas, alfalfa and others. The slave-stricken lands are being regenerated, and gradually but slowly stock suited to the climate and conditions of the Atlantic cotton States is being introduced.

Of course all these changes imply the use of fertilizers in larger and larger measure. That need is being met. The vast deposits of phosphatic material in Kentucky, Tennessee, Florida and the Carolinas, coupled with the use of the ground slag from basic steel furnaces, give an assurance of an abundant supply of that necessary element for all time to come.

The discovery of the function of the bacteria attached to the stalks

of leguminous plants, dissociating the nitrogen of the atmosphere and converting it through the plant to the renovation of the soil, coupled with artificial sources, give assurance of adequate supply of that necessary element, while discoveries in science promise yet greater abundance in the conversion of the secondary products of gas plants to fertilizers.

The last element which is necessary, potash, of course exists in great abundance throughout many sections of the country, but the solubility of potash capable of being assimilated by plants and the cost of deriving it from its original source in the rocks, have rendered the country for the time being largely dependent on the Stassfurt Mines of Saxony, where the existence of a pan underlying the salt in which the potash has accumulated, has rendered that place the source of this necessary element in fertilizers at the lowest cost. It is, however, hardly to be doubted that in the great range of alkali soils and deserts extending from British Columbia around the circle far into Texas, deposits of potash will soon be discovered which can be worked. Permanent potash springs are very numerous, and in the arid country it may be assumed that while the potash may have leached down to a moderate distance, it has not been carried away. A strong company, with abundant capital, under competent engineers, has lately been organized for following the surface indications of potash by boring at many points.

In a broad and general way it may be safely affirmed that the great farming States of the Mississippi Valley which have been named, will produce this year within a fraction of all the wheat now required for the consumption of the people of the United States, and that by improvement in the methods of agriculture their product will keep even with the increase of population without calling for more land. Outside this area are vast sections from which the quantity of wheat now available for export may be derived. In these sections the intensive system has not yet taken the place of the former methods of cultivation. It may be safely affirmed that Montana, Washington, Oregon, California and other sections of the Northwest and of the Pacific coast, can produce all the wheat that Europe can possibly pay for during the present generation. It is only a question of price. Our crop now being marketed officially estimated at 704,000,000 is probably 750,000,000 bushels or about 95,000,000 quarters. The prevailing drought did not come until the winter wheat was harvested and the spring wheat fairly secure; it will reduce the corn or maize crop. At a dollar a bushel or at thirty-two shillings per quarter in Mark Lane, we could add 20,000,000 quarters in a year or two if we had the farm laborers to do the work not yet done by machinery.

Again, although the cotton States of the Atlantic coast will not be great producers of grain, especially of wheat, yet in the Southwest—in Texas, Oklahoma, the Indian Territory and Louisiana—we could readily produce the entire wheat crop of the United States upon unoccupied land, whenever labor and capital can be found sufficient to develop the product. As our country people say, a dollar a bushel would fetch it. Some of the best hard or macaroni wheat in the world is already produced in this section.

I have called the attention of economists to the basis of this development of agriculture, namely, what may be called the free land tenure established in the United States. An outsider should deal with the conditions of other countries with great caution, but in the study which I have given to the subject it has seemed to me very plain that the feudal land system of the United Kingdom of Great Britain and Ireland had come to its necessary end, witnessed by the present movement for the practical confiscation of land titles in Ireland. One may ask, what would be the potential of the land of the United Kingdom in the production of food for its own population, if the purchase and sale of land were as free as it is in the United States?

Again, it appears to an outsider as if the revulsion from the feudal system in France and large parts of Germany, where the land is cut up in little patches, had also failed in developing the potential of the soil, the application of modern mechanism to its full effect being rendered impossible by the great subdivision of the soil.

You will remark that the area of the United States, omitting Alaska, covers three million (3,000,000) square miles; the habitable part of Canada may be computed at over two million (2,000,000), to which we may add Mexico, giving in all, say over five million (5,000,000) square miles, of which more than one-half is available for cultivation. At nine thousand (9,000) to ten thousand (10,000) bushels to a square mile, which is rather a low standard of intelligent cultivation, ten (10) per cent. of this area, or two hundred and fifty thousand (250,000) square miles, would yield about the present wheat crop of the world. I think we could spare that area without missing it, even within the limits of the United States, if we could make a contract for a term of years at thirty-two (32) shillings a quarter in London for all the wheat Europe could possibly buy.

Even if this forecast be considered visionary, it may be surely held that the United States can supply for many years to come the entire deficiency in the wheat crop of the United Kingdom, twenty-five million (25,000,000) to thirty million (30,000,000) quarters a year, probably by improvement in intensive farming, without adding materially to the land which may be devoted to the wheat crop.

In this paper I have given the details of the grain problem. Cotton

comes next in importance, especially to the people of Great Britain. The all-cotton, old plantation system is extinct. A mere fraction of the present cotton crop is growing in the old way; almost the whole comes from the small farmers, black as well as white. The tenant system was almost universally adopted in the process of reconstruction; improvement in agriculture is slow but sure. The dream of the freedman was forty acres and a mule, and in fact great numbers are attaining that end.

For many years after the end of the Civil War the cotton States still depended upon the North for hay and upon the West for corn and meat. There is probably no great force of laborers in the world who can fully subsist at so low a cost as the Southern negroes. 'Hog and hominy,' as it is called, bacon and cracked corn, are their choice above all other kinds of food. On this ration, coupled with such fruits and vegetables as they can secure, they are content. A peck of corn meal, three and one-half pounds of bacon and a quart of molasses or sorghum syrup is the customary ration for one week, costing six to nine cents a day. All that is changing. The intelligent farmers now produce their own bread and meat; some of them in excess. They are developing leguminous plants—pea vines, beans, alfalfa, crimson clover and the like; gradually introducing stock, and soon to fold sheep upon the cotton fields, to the renovation of the soil.

The very large proportionate number of tenants which has been disclosed by the former census and will be yet more marked in the present census is mainly the result of the changing conditions in the cotton States; a passing phase in the South, as it is in the West; not of long duration, and not implying any permanent condition of landlordism.

In fact, in conclusion it may be dogmatically stated that both wheat and cotton are becoming the excess, surplus or money crops of farmers whose products otherwise suffice to sustain the farm. It is therefore difficult to measure the exact cost of raising wheat. It has been produced at less than one shilling per bushel, including use and repairs of machinery and interest thereon, but not including any charge for the rental of land, which forms a part of the income or profit of the farmer. It may be dogmatically affirmed that so long as the farmer in the Mississippi grain-growing States can secure to his own use and enjoyment one cent a pound, sixty cents a bushel, four dollars and eighty cents, or twenty shillings a quarter, the present average product of wheat will be maintained, subject to variation in quantity according to the season. At seventy cents a bushel new land will be put under cultivation in wheat to any extent of the demand, and capital will be found. The difficulty will be to procure even the necessary labor still required, notwithstanding the increasing use of machinery and

the common practice of small farmers in combining for the ownership of mowers and reapers or in contracting for the harvest.

No subject of greater importance could be brought before the English-speaking people; none of greater weight in maintaining our interdependence with our kin beyond the seas. The right comprehension of this problem will give assurance of peace, good-will and plenty.

It may be interesting to call your attention to the fact that the Pilgrim Fathers spent several years in Holland before they migrated to New England. The larger part both of Pilgrims and Puritans came from the southeastern counties of England, where institutions had been greatly modified by Dutch, Flemish and Huguenot immigrants. The Dutch themselves settled New York and other colonies. We derive our common schools, our toleration of religion, our welcome to invention and our free division of land chiefly from the Dutch, rather than from our English ancestors. It is true that the Puritans were intolerant and that the Dutch attempted to establish large manors in the State of New York, under patroons, so-called; but the more liberal tendencies of the Pilgrims in New England, the Quakers in Pennsylvania, the Baptists of Rhode Island, the Dutch in New York and the Catholics in Maryland overcame the intolerance of the Puritans, while the free system of land holding also displaced all other tenures.

THE INERT CONSTITUENTS OF THE ATMOSPHERE.

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THE discovery of an element always awakens interest; for the total number of the known elements does not exceed seventy-five, and all the various forms of matter which exist on this globe are necessarily composed of these elements. An element, as is well known, is the ultimate constituent of a compound; and with only a limited number, Nature has provided us with that enormous wealth of minerals, of vegetables and of animals, all of which have as their constituents two or more of these elements.

These elements, however, must not be regarded as isolated entities, each self-dependent, having no relations with its compeers; on the contrary, all the elements exhibit certain connections with their neighbors; and there is to be traced an orderly progression from one class of elements, strongly electro-positive in character, metallic in appearance, very inflammable when heated in the air, and at once attacked by water, to another class, highly electro-negative, transparent, unattackable by oxygen, and without perceptible action on water, through a number of connecting links, each of which serves to soften the transition.

These elements have been arranged in series, and it is by considering the method of arrangement that our interest is awakened. The earliest attempt to make such an arrangement antedates the very idea of the conception of an element. For the division of all matter into metal and non-metal is one which is lost in the mists of antiquity. The word 'metal' is derived from the Greek verb *μεταλλάω*, I search; and that verb is said to be derived from *μέτα* and *ἄλλα*, signifying 'after other things.' As it was recognized that elements are constituents of more complex matter, a conception first emphasized by Boyle, and as the distinction became clear that matter which resists decomposition must be classed as elementary and, after a century and a half, a number of elements were recognized, it was obvious that a number of them might be grouped in classes. Take, for example, the elements chlorine, bromine and iodine, all colored, strongly smelling substances, sparingly soluble in water and forming compounds barely distinguishable from each other in appearance or by a cursory inspection; or take such a group as the metals of the alkalies, lithium,

sodium, potassium, rubidium and cæsium, all white, soft metals, all easily oxidizable, all at once violently attacked by water, and generally with such energy as to be inflamed at the contact. It required no great penetration to class such elements as these into classes.

The revival of the hypothesis of the atomic constitution of matter by Dalton and of his attempt to determine the atomic weights of the elements was not long in provoking the guess that perhaps there could be found some connection between the numbers representing the relative atomic weights of kindred elements. But, as is well known, the state of knowledge in Dalton's day was not sufficiently advanced to enable him to attribute to elements their correct relative atomic weights; and it was not until the eminent professor of chemistry in Rome, Cannizzaro, whose jubilee has recently been celebrated, pointed out the bearing on Dalton's numbers of all the facts accumulated up to the year 1856 that the close relationship between the atomic weights and the properties of the elements was suggested by John Newlands. Some years later, Lothar Meyer and Dmitri Mendeléef amplified and elaborated the ideas which had first been propounded by Newlands; and the periodicity of the atomic weights and the gradual variation of the properties of the elements and their compounds were established on a firm basis.

Various plans have been adopted to render this arrangement pictorially visible; each method has perhaps its own conveniences, but none can be regarded as the method *par excellence*. Lothar Meyer's original table is constructed on the hypothesis that a cylinder, on which the numbers have been distributed in their order on a descending spiral in eight main columns, has been unrolled.

Another method of representation is due to Dr. Johnstone Stoney. The atomic weights are represented on a spiral curve, closely approximating in form to a logarithmic spiral, and the magnitudes of the atomic weights are represented by the volumes of concentric spheres. Thus, the sphere in the middle stands for unity, the atomic weight of hydrogen. The elements follow each other according to the numerical order of their atomic weights; and by joining the points thus obtained, a nearly regular spiral curve is produced, resembling one derived by aid of a logarithmic or elliptical formula. The deviations from regularity appear also to follow a law, and if accurately mapped the spiral is a sinuous one. But the determination of individual atomic weights is as yet not sufficiently accurate to make it possible to calculate the course of the wavy line.

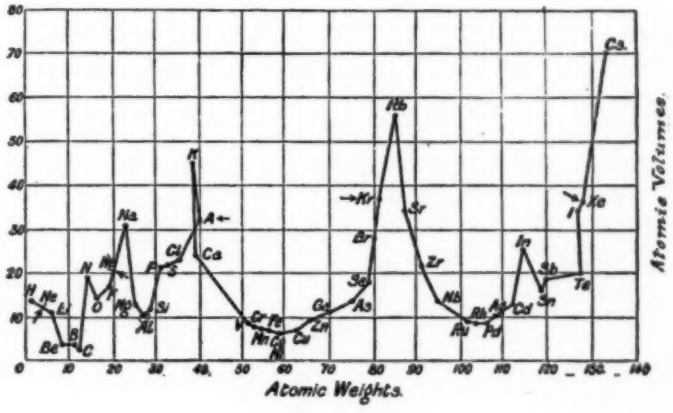
A third diagram, modified from that of Meyer, has been constructed by Professor Orme Masson, of Melbourne. The chief difference is that instead of grouping elements of the iron, palladium and platinum groups, they are distributed; hydrogen forms the first element of the

fluorine column; and the long and short periods are kept separate by a fold in the diagram. A diagonal line, too, divides the 'metallic' from the 'non-metallic' elements.

Other devices have been suggested in order to represent diagrammatically the relations between the atomic weights; but it must be borne in mind that whatever system is employed, such plans are merely aids to thought, and have no real significance. They are on a par with the representation of numerical relations as curves, and can convey nothing which is not already contained in the actual numbers.

It was Mendeléef who first drew attention to the progressive alteration of the valency of the elements in passing from left to right along the table. While the metals of the alkalies, lithium, sodium, potassium, rubidium and cæsium, are all monads, in as much as one atom of any one of these elements is able to replace one atom of hydrogen, the typical monad, elements of the beryllium group are dyads; hence while the formula of sodium chloride is NaCl, that of calcium chloride is $CaCl_2$, that of boron chloride, BCl_3, for boron is a triad; the chloride of the tetrad, carbon, CCl_4, and so on. And considering the compounds with hydrogen, where these exist, we have BH_3, corresponding to the chloride; CH_4, NH_3, OH_2, and finally ClH and FH. As the valency alters by unity in each case, it appeared reasonable to place the elements on the table in equidistant columns; or, as in Dr. Stoney's diagram, on equidistant lines, dividing the spiral curve into eight equal segments.

Meyer, however, showed that if the elements be mapped on square



paper, so that the vertical divisions correspond to the volumes occupied by unit weight of the solid or liquid elements, while the horizontal divisions correspond with the atomic weights, a certain amount of

regularity is to be noticed, as is to be seen in the accompanying diagram. There, it will be noticed, the elements, sodium, potassium, rubidium and cæsium, occur at the summits of somewhat irregular curves. Such relations, among others, led him to formulate the proposition that the properties of the elements are periodic functions of their atomic weights; that is, they vary in a systematic manner, either positively or negatively, as the scale of the atomic weights is ascended.

The division of the elements into metals and non-metals corresponds broadly with another well-marked division—that into basic and acidic. Generally speaking, it is the oxides of the metallic elements which react with water to form bases; and those of the non-metals which form acids with water. This distinction was recognized by Lavoisier, when he named oxygen the acid-forming element. But what is a base? And what is an acid? The old definition was—two classes of substances, which, when brought together, react to form a salt. But the definition may now be made with greater definiteness. It was known to Cavendish and to Priestley, that when a current of electricity was passed through the solution of a salt in water, one portion of the salt, namely the basic portion, came towards the negative pole; and it was believed that this was due to the basic portion possessing a positive charge. Similarly, the acid portion, possessing a negative charge, traveled towards the positive pole. Hence, bases were said to be electro-negative, and acids, electro-positive. And Sir Humphry Davy arranged the elements in a series, of which one was supposed to be electro-positive to its neighbor on the right, and electro-negative to its left-hand neighbor.

According to modern ideas, bases, by the mere act of solution in water, are supposed to be split up into two portions, for which the term ion, invented by Faraday, has been retained; one ion is charged by the process of solution with a positive charge, and that portion is usually a metal; the other portion, which consists of one or more groups of hydrogen and oxygen in combination, termed 'hydroxyl'—OH—has a negative charge. A base, indeed, is a compound which splits in this manner. On the other hand, an acid, when dissolved in water, undergoes an analogous split; but in this case the electro-positive ion is always hydrogen, while the electro-negative ion may either be an element such as chlorine, or a group of elements such as exist in nitric acid (NO_3).

The order of the various elements in the electric series has been determined; and not merely determined, but to each has been attached a numerical value. This value is identical with what is termed 'chemical affinity'; and it represents the electric potential of the element with reference to an arbitrary starting-point, which does not differ much from that of nickel, an element closely related to iron. Only

a few such values have as yet been determined numerically; instances may be chosen from the magnesium group, where the numbers run: Magnesium = + 1.2; Zinc = + 0.5; Cadmium = + 0.19; or from the fluorine column, where the numbers are: Fluorine = — 2.0; Chlorine = — 1.6; Iodine = — 0.4. In each case the potential, positive or negative, is the highest for the element with smallest atomic weight, and decreases with increase of atomic weight, for elements in the same column. The order of some of the elements is: Cs Rb K Na Li Ba Sr Ca Mg Al Mn Zn Cd Fe″ Co Ni Pb H Cu Ag Hg′Pt‴′ Au′″; and for electro-negative ions, S″ O″ I Br Cl F; the first element, cæsium, being the most electro-positive, and the last, fluorine, the most electro-negative.

The order given above corresponds fairly well with the order in the periodic table, passing from left to right. But, as in the table, the atomic weights follow each other continuously round the cylinder or round the spiral, the abrupt change from elements of an extreme electro-negative character, like fluorine to sodium, an element of highly electro-positive character, or from chlorine to potassium, has always appeared remarkable. The old dictum, *Natura nihil fit per saltum,* if not always true (else we should have no elements at all, but a gradual and continuous transition from one kind of matter to another—a condition of affairs hardly possible to realize), has generally some spice of truth in it; and it might have been predicted (and the forecast seems to have been made obscurely by several speculators) that a series of elements should exist which should exhibit no electric polarity whatever. Such elements, too, should form no compounds, and, of course, should display no valency; they should be indifferent, inactive bodies, with no chemical properties.

The discovery of argon in 1894, followed by that of terrestrial helium in 1895, and of neon, krypton and xenon in 1898, has shown the justice of the foregoing remarks. In as much as the methods employed for the isolation of these elements illustrate their properties and confirm the views as to their inertness and lack of electric polarity, I propose to sketch shortly the history of their discovery.

An accurate investigation of the density of atmospheric nitrogen and of nitrogen prepared from its compounds led Lord Rayleigh to inquire into the cause of the discrepancy, for the density of the nitrogen of the atmosphere was found to exceed that of 'chemical nitrogen' by about one part in two hundred, whereas the accuracy of his experiments was such that it would have excluded an error of one part in five thousand. I need not here allude to the reasons which were at first put forward to account for this anomaly; suffice it to say that they offered no explanation; and that we ultimately traced the discrepancy to the presence in 'atmospheric nitrogen' of a gas nearly half as dense again

as nitrogen. Two methods were adopted for isolating this gas. One was a repetition of a process which had been employed by Cavendish in 1785; it consisted in passing electric sparks for a long time through air, confined over mercury, in presence of caustic alkali. The accompanying woodcut gives an idea of the apparatus he employed. This experiment had been made by Priestley ten years previously, but not with quantitative accuracy. It was Cavendish's object to inquire whether the nitrogen of the atmosphere had any claim to be regarded as a homogeneous substance, but he left the question undecided. Having continued to pass sparks through a measured volume of air, with the occasional addition of oxygen, until no further diminution in volume occurred, he found that after the excess of oxygen had been removed, the residue amounted to not more than 1/120th part of the whole of the nitrogen. The actual volume of the inactive gases in the nitrogen of the atmosphere is one eighty-fourth. Cavendish did not pursue the investigation further, and the discovery of argon was postponed for a century.

FIG. 1.

A convenient form of apparatus for repeating Cavendish's experiment is shown in the accompanying figure. The gas, air mixed with oxygen, is confined over mercury in an inverted test-tube, in contact with a few drops of a solution of caustic potash; and by connecting the rings with wires from the secondary coil of an induction apparatus, sparks pass between the platinum terminals in the interior of the test-tube. The volume of the gas rapidly diminishes; and in a few hours, the gas is removed to a clean tube, and the excess of oxygen absorbed by burning phosphorus; the inert gases remain behind.

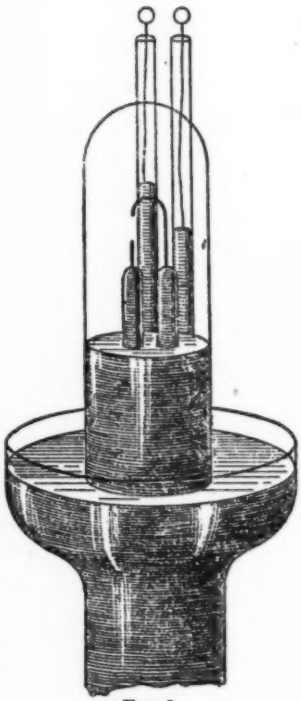


FIG. 2.

On a larger scale, the apparatus used by Lord Rayleigh, consisting

of a balloon of six liters capacity, in the interior of which an electric flame is kept alight by means of a transformer, while a jet of caustic alkali forms a fountain in the interior, gives good results. By its help, seven or eight liters of mixed gases can be made to combine per hour.

Such experiments show the inactive nature of the argon group of gases towards an electro-negative element, oxygen. The gases are absolutely incombustible. No other elements can withstand such treatment, save platinum and its congeners, and gold. But even these metals combine with fluorine or chlorine, when heated in a current of one or other gas. Argon, however, is wholly unaffected when electric sparks are passed through its mixture with chlorine or fluorine, the two other most electro-negative elements. To them, too, it shows itself completely indifferent.

A more convenient method of separating the nitrogen from its admixture with argon in atmospheric air is by means of red-hot magnesium. The metal magnesium, which is now made on a considerable scale for photographic and signaling purposes, is a white, silvery metal, which can be planed or turned into shavings. In the early experiments, a measured quantity of atmospheric nitrogen, dried by passing over suitable drying agents, was brought into contact with magnesium turnings, heated to redness in a tube of hard glass. It has been found, however, by M. Maquenne, that the metal calcium, which, for this purpose is most easily produced by heating together a mixture of magnesium filings and pure dry lime, is a more efficient absorbing agent for nitrogen, for it does not require such a high temperature, and can be effected without danger of melting the glass tube. Indeed, the operation is a very easy one, and can be carried out with the very simple apparatus shown in Figure 3. M. Guntz has also found that lithium, an element belonging to the same column in the periodic table as sodium and potassium, is an exceedingly good absorbent for nitrogen, for it tarnishes in nitrogen even at atmospheric temperature, owing to the formation of a nitride.

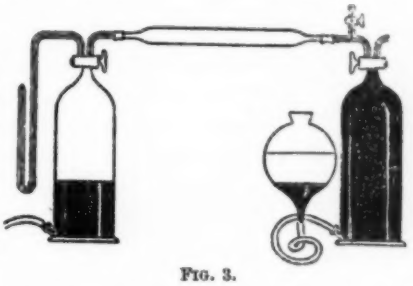


FIG. 3.

On a large scale, the magnesium turnings are contained in iron tubes, and the gas-holders are made of copper or of galvanized iron. By this means, fifteen liters of argon were separated from about two cubic yards of air.

The inactivity of argon in contact with such highly electro-positive elements as lithium, magnesium and calcium again demonstrates its

want of electric polarity. No other elements would have resisted such treatment, except those of the argon group. But these are not the only data from which such a conclusion can be drawn; for it was found that no action takes place between argon and hydrogen, phosphorus, sulphur, tellurium, caustic soda, potassium nitrate, sodium peroxide, sodium persulphide, nitro-hydrochloric acid, bromine-water and many other reagents which it would be tedious to mention, all of which are remarkable for their chemical activity. We may therefore take it that the name 'argon,' which means 'inactive,' has been happily chosen.

In attempting to form compounds of argon, however, another consideration was not lost sight of; if compounds of argon were capable of existence, they ought to exist in nature; and as in all probability they would be easily decomposed by heat, it ought to be possible to decompose them with evolution of argon, which could be collected and tested. Professor Miers, in a letter which he wrote me the day after an account of the fruitless attempts to cause argon to combine had been given to the Royal Society, drew my attention to experiments by Dr. Hillebrand of the United States Geological Survey, in course of which he obtained a gas, which he believed to be nitrogen, by treating the rare mineral clevite, a substance found in felspathic rocks in the south of Norway, with sulphuric acid. The chief constituents of clevite are oxides of the rare elements uranium and thorium, and of lead. The gas obtained thus, after purification from nitrogen, was examined in a Plücker tube with the spectroscope, and exhibited a number of brilliant lines, of which the most remarkable was one in the yellow part of the spectrum, similar in color to the light given out by the glowing tube. The position of this line and of others which accompany it established the identity of this gas, not with argon, as was hoped, but with a supposed constituent of the sun's chromosphere, first observed by M. Janssen of Paris, during an eclipse which was visible in India in 1868. The late Sir Edward Frankland, and Sir Norman Lockyer, who studied the spectrum of the chromosphere, gave to the supposititious element, which they regarded as the cause of these lines, the name 'helium,' a word derived from '*ἥλιος*,' Greek for 'the sun.' Having been placed on the track, I examined, with the assistance of Dr. Collie and Dr. Travers, no fewer than 51 minerals; while Sir Norman Lockyer examined 46 additional ones, which we had not examined; and in 19 minerals, almost all of them containing uranium, helium was found. Only one gave an argon spectrum, namely malacon. We also sought for argon and helium in meteorites, which all give off gas on heating; but in only one specimen, a meteorite from Augusta County, Virginia, was helium found, in this case accompanied by argon. All natural waters contain argon, for

that gas is somewhat soluble in water (4.1 volumes per 100 of water at 15° C.); but some also contain helium, as for instance the gas from the Bath springs, which Lord Rayleigh found to contain argon mixed with about 8 per cent. of its volume of helium; and helium has also been found in mineral springs at Wildbad, and at Cauterets, in the Pyrenees. It would appear, then, that helium is not such a very rare constituent of our globe; and indeed, it is probable that it is continually escaping from the earth in small quantities in certain regions.

Let us next turn our attention to the atomic weights of these elements, in order to discover what position should be assigned to them in the periodic table. It is not difficult to ascertain their molecular weights; that is the relative weights of equal numbers of molecules; for, assuming Avogadro's hypothesis, that equal volumes of gases contain equal numbers of molecules, or particles capable of independent existence in space, the weights of equal volumes of these gases, compared with that of an equal volume of oxygen taken as 16 (the usual standard) will give the relative weights of their molecules. The density of helium was found to be very nearly 2, or one eighth of that of oxygen; while that of argon was 19.94, very nearly 20. It may be interesting to spend a few minutes in a description of the method by which the density is determined. The principle is to weigh a globe, completely emptied of air by means of an air-pump; the globe is then filled with the gas, care being taken to observe accurately the temperature and pressure of the atmosphere at the moment of closing the globe; and the difference in weight of the full and the empty bulb gives the weight of a known volume of the gas. It is easy to compare it with that of an equal volume of oxygen.

The weight of a gas is much more considerable than might be supposed. Thus, a liter of oxygen weighs nearly a gram and a half; and the air in an ordinary room twelve feet broad, long and high, weighs over a hundred and fifty pounds. It is possible to obtain fair results by weighing as little as 30 cubic centimeters, or about one fluid ounce of any gas. Such a globe filled with helium weighs about one two-hundredths of a gram; and it is not difficult to be fairly certain to one-hundredth part of that weight. With a heavier gas like argon, much greater accuracy is of course possible.

Now, although the standard atomic weight with which others are compared, that of oxygen, is taken as 16, it is believed, for reasons which will afterwards appear, that a molecule of oxygen consists of two atoms, the weight of which will of course be 32. And, as the weight of helium is one eighth of that of an equal volume of oxygen, the weight of a molecule of helium will be the eighth part of 32, or 4. Similarly, the molecular weight of argon compared with that of an atom of oxygen taken as 16 will be 40. But the question has still to

be answered: Does a molecule of helium or of argon resemble a molecule of oxygen in consisting of two atoms; or does it consist of one atom or of more than two?

It is believed that when heat is put into a gas, it is expended in causing the molecules to move. This motion may in some cases be of two kinds; the molecules may be urged through space, each molecule traveling in a straight path, until a collision takes place with another molecule, when it changes its rate and direction of motion; such motion is termed 'translational motion.' On the other hand, if the molecules are themselves complex, that is, if they consist of groups of atoms, any energy imparted to the gas in the form of heat will produce, not merely the translational motion, but will also cause the atoms to move relatively to each other within the molecule. It is only the translational motion which is manifested as pressure, for it is only by their motion through space that the molecules can bombard the sides of the vessel which contains them, and so exert pressure on the walls. Hence it will require a less amount of heat to raise pressure in a gas with simple molecules, than in one of which the molecules are complex, for in the former case no heat is used in causing internal motion. Now, to measure such quantities of heat is by no means easy, although it has been successfully accomplished in some instances. To avoid this measurement, a device is adopted which produces equally satisfactory results. It consists in comparing the amounts of heat required to raise the temperature of a gas, first, when it is not allowed to expand, and when all the heat is used in producing molecular motion of the kind referred to; and second, when it is allowed to expand, and consequently when it could be made to do work; for example, to drive a small air-engine. In the latter case, a greater amount of heat is required to rise the temperature of the gas; an amount equivalent to the work which the gas does on expanding. This quantity, however, which is equivalent to mechanical work, is the same for all gases, provided equal numbers of molecules (or equal volumes) be heated through the same number of degrees of temperature. And this renders it possible to calculate the amount of heat required to raise the temperature of a gas, even without a direct measurement. An example will serve to render this somewhat difficult conception clear. For mercury-gas, for argon and for helium, and indeed for all gases, nitrogen, oxygen and their mixture, air, if a volume which contains the molecular weight of the gas taken in grams be raised through one degree of temperature, allowing the gas to expand, and so to do work, the amount of heat equivalent to this work is sufficient to raise the temperature of two grams of water through one degree. This is termed in the language of heat-measurement 2 calories. Now, the total heat required to raise the temperature of 40 grams of argon, for example (and it must be remembered that 40 is

the molecular weight of argon), through 1°, allowing it to expand while it is being heated, is 5 calories. Deducting the 2 calories required for external work, 3 calories remain as the heat required to raise the temperature of the gas. For oxygen, on the other hand, the heat required to raise the temperature of 32 grams, its molecular weight, through 1° is 7 calories; and deducting 2 as before, the remainder is 5, the specific heat of oxygen. Hence for argon and for oxygen, we have the properties:

	HEAT REQUIRED.						
	No external work.		External work.				
Argon	3	:	5	::	1	:	1⅔
Oxygen	5	:	7	::	1	:	1⅖

The argument stands thus: The heat required to raise the temperature of argon without expansion can be accounted for entirely on the supposition that it is wholly used in causing the molecules to move through space; on the other hand, more heat requires to be communicated to oxygen than to argon in the proportion of 3 to 5. With oxygen and similar gases, this extra heat must be doing something; it is supposed to produce motion of the atoms within the molecule. There is no such motion within the argon molecule; hence it is concluded that the molecule consists of a single atom; and in that case, the molecular weight is the same as the atomic weight. The molecule of oxygen may be considered as possessing a structure like that of a dumb-bell; the atoms forming the knobs at each end of the bar. On throwing a dumb-bell through space, it will not merely change its position as a whole; but it will rotate. But a molecule of argon or helium is imagined to have the simpler form of a sphere or ball; when it is thrown practically no energy is used in causing it to rotate, but it is all expended in making it pass through space.

I must apologize for introducing such abstruse conceptions into a popular exposition; but they are necessary to the argument; and I am afraid that no simpler means can be found of reaching the conclusion that the molecules of argon and of helium are identical with their atoms.

As 4 is the molecular weight of helium, and as 40 is that of argon, these numbers also stand for their atomic weights. Let us next see how these figures fit into the periodic table.

In 1897, as president of the Chemical Section of the British Association, I chose the title 'An Undiscovered Gas' for the address to the Section. The arguments in favor of the existence of such a gas were briefly these: The differences between the atomic weights of consecutive elements in the columns of the periodic table are approximately 16 to 20; thus 16.5 is the difference between the atomic weights of fluorine and chlorine; 16, between those of oxygen and sulphur, and so on.

Again, stepping one pace down the scale, we have 19.5 as the difference between chlorine and manganese; 20.3, between sulphur and chromium; 19.8, between silicon and titanium, etc. The total difference between manganese and fluorine is 36; between chromium and oxygen, 36.3; between vanadium and nitrogen, 37.4, and between titanium and carbon, 36.1. This is approximately the difference between the atomic weights of helium and argon, 36. I quote now from that address: "There should, therefore, be an undiscovered element between helium and argon, with an atomic weight 16 units higher than that of helium, and 20 units lower than that of argon, namely 20. And if this unknown element, like helium and argon, should prove to consist of monatomic molecules, then its density should be half its atomic weight, 10. And pushing the analogy still further, it is to be expected that this element should be as indifferent to union with other elements as the two allied elements."

Those who care to read the story of the search for this undiscovered element may find it in the address. Minerals from all parts of the globe, mineral waters from Britain, France and Iceland, meteorites from interstellar space; all these were investigated without result. Helium from various minerals was separated by long and tedious processes of diffusion into a possibly lighter portion, diffusing more rapidly, and a possibly heavier portion, diffusing more slowly; but with no positive result. The systematic diffusion of argon, however, gave a faint indication of where to seek for the missing element, for the density of the more rapidly diffusing portion was 19.93, while that of the portion which diffused more slowly was 20.01.

The invention by Dr. Hampson of an apparatus by means of which it is possible to obtain liquid air at small expense and with little trouble placed a new instrument in our hands; and Dr. Travers and I prepared 15 liters of argon from the atmosphere, with the purpose of distilling it fractionally, after liquefaction; for we knew, from the researches of Professor Olszewski of Cracow, who has done so much to determine the properties of liquefied gases, that argon could be liquefied easily by compressing it into a vessel cooled by help of liquid air. And, moreover, we were in hope that by fractionating the air itself, gases of even higher atomic weight than argon might possibly be obtained. Both expectations were realized; on distilling liquid argon, the first portions of gas to boil off were found to be lighter than argon; and on allowing liquid air to boil slowly away, heavier gases came off at the last. It was easy to recognize these gases by help of the spectroscope; for the light gas, to which we gave the name, *neon,* or 'the new one,' when electrically excited emits a brilliant flame-colored light; and one of the heavy gases, which we called *krypton,* or 'the hidden one,' is characterized by two brilliant lines, one in the yellow

and one in the green part of the spectrum. The third gas, named *xenon*, or 'the stranger,' gives out a greenish-blue light, and is remarkable for a very complex spectrum, in which blue lines are conspicuous.

Although neon was first obtained by the fractional distillation of argon, it was afterwards found convenient to prepare it direct from air. The torpedo-compressor, which is used for compressing the air before it enters Dr. Hampson's liquefier, was made to take in the air which had escaped liquefaction in the liquefier; the denser portions were thus liquefied, and the lighter portions were liquefied by compressing them into a vessel cooled by the denser fractions, boiling under reduced pressure, and consequently at a specially low temperature. This liquefied portion was again fractionated, and yielded neon; and it was not long before we discovered that helium was also present in the mixture. The presence of helium in atmospheric air had previously been noted by Professor Kayser of Bonn, and by Professor Friedländer of Berlin, on submitting the spectrum of argon to a searching examination.

The purification of this mixture of neon and helium from argon, although a lengthy process, was not attended by any special difficulty. It was accomplished by repeated distillation, the lighter portions being always collected separately from the heavier portions, and again distilled by themselves. But after this separation had been accomplished, we found that we were unable by means of liquid air to liquefy the mixture, or indeed any portion of it. We effected a partial separation by diffusion; but it is not possible to separate by this method two gases of which the quantity is limited. Another attempt was made by dissolving the gases in liquid oxygen, on the supposition that neon might prove more soluble than helium; but without satisfactory results. It was evident that a lower temperature than that possible by help of liquid air was necessary.

Professor Dewar had by that time succeeded in producing liquid hydrogen in quantity, and had indicated the principle, which is identical with that of Dr. Hampson's air-liquefier, although he has not published any detailed account of his apparatus. Dr. Travers undertook to investigate the subject; and after four unsuccessful trials, he made a liquefier, with the help of Mr. Holding, the laboratory mechanician, by means of which a hundred cubic centimeters of liquid hydrogen could be easily and cheaply produced. There was then no difficulty in effecting the separation of neon from helium; for, while neon is practically non-volatile, when cooled by liquid hydrogen, remaining in the state of solid or liquid, even that enormously low temperature is not sufficient to convert helium into a liquid. Hence the gaseous helium could be pumped away from the non-gaseous neon, and the latter was obtained in a pure state.

The residues obtained from the evaporation of about thirty liters of liquid air, after being freed from oxygen and nitrogen, were liquefied by help of liquid air, and fractionated from each other. The separation offered no special difficulty, but was long and tedious. It soon appeared that when most of the argon had been removed, the residue solidified when cooled; but while it was possible to remove the krypton by pumping, for it goes into gas slowly even at the low temperature of liquid air, very little xenon accompanied it; for at that temperature, xenon is hardly at all volatile.

Having finally separated the gases, their densities and other properties were carefully determined; and it was also proved that they are like argon and helium, in as much as their molecules consist of single atoms. Neon, as was expected, turned out to be the missing link between helium and argon; the atomic weight of krypton was found to be 81.6, and that of xenon, 128. The volumes occupied by equal numbers of molecules of the liquefied gases were determined; and also the boiling-points and melting-points of argon, krypton and xenon. These figures are shown in the following table:

	Helium.	Neon.	Argon.	Krypton.	Xenon.
Density of gas.....	1.98	9.96	19.96	40.78	64.0
Atomic weight.....	3.96	19.92	39.92	81.56	128.0
Density of liquid.....	0.3 (?)	1.0 (?)	1.212	2.155	3.52
Boiling-points.....	—	—	—186.1°C.	—151.7°C.	—109.1°C.
Melting-points.....	—	—	—187.9°C.	—169.°C.	—140.°C.
Critical temperatures..	—	—	—117.4°C.	— 62.5°C.	+ 14.75°C.
Critical pressures.....	—	— (Metres.)	40.20	41.24	43.50
Refractivity of gas.....	0.124	0.235	0.968	1.450	2.368

In every case there is seen what is termed periodicity; that is, a gradual alteration with rise of atomic weight, of the densities of the liquids, of the melting-points, of the boiling-points, and of the retardation of light when passed through the gas.

Let us consider, in conclusion, the position of these elements in the periodic table; and it will be sufficient to confine our attention to the groups of elements which form the neighboring columns. The atomic weights are given in round numbers.

Hydrogen.	Helium.	Lithium.	Beryllium.
1	4	7	9
Fluorine.	Neon.	Sodium.	Magnesium.
19	20	23	24
Chlorine.	Argon.	Potassium.	Calcium.
35.5	40	39	40
Bromine.	Krypton.	Rubidium.	Strontium.
80	82	85	87
Iodine.	Xenon.	Cæsium.	Barium.
127	128	133	137

It is evident that these new elements fall into their natural places between the strongly electro-negative elements of the fluorine group, and

the very electro-positive elements of the lithium group; and that, in consequence of their lack of electric polarity, and their inactivity, they form, in a certain sense, a connecting link between the two. It is curious, too, to notice that iodine, xenon, cæsium and barium form the ends of their respective columns. It is, of course, not impossible that other elements may be discovered, possessing similar properties, and yet higher atomic weights than these; but as yet there is no clue to guide us where to search for them.

It is difficult, owing to the impossibility of effecting a complete separation of the inactive elements from each other, to do more than hazard a guess as to their relative amount in air. As they are easily separated from the other constituents of air, there is no doubt as to their total amount; air contains 0.937 parts of argon and its companions by volume in 100 parts. Perhaps the table below may be taken as affording some indication of their relative amounts. Air contains by volume:

0.937 parts of argon per hundred.
One or two parts of neon per hundred thousand.
One or two parts of helium per million.
About one part of krypton per million.
About one part of xenon per twenty million.

It is of course not impossible that xenon may contain an even smaller proportion of a still heavier gas; but it is unlikely. Sea-water sometimes contains a grain of gold per ton; that is one part in 15,180,000; a grain of xenon is contained in about four hundredweights of air.

The problems suggested by the periodic table are by no means solved by the discovery of these aerial gases; but something has been done to throw light upon one obscure corner of the field. The gap between the electro-positive and the electro-negative elements has been bridged.

DISCUSSION AND CORRESPONDENCE.

A VIKING PHILOSOPHER.

In the minds of most men the name of Adolf Erik Nordenskiöld is connected with the voyage of the *Vega*, and with that only. That is a good title to fame, for his circumnavigation of the Old World, the forcing of the northeast passage, attempted in vain for over three centuries, was an exploit worthy to rank with those of Vasco di Gama and Maghelhaëns. But Nordenskiöld was a good deal more than a great explorer, and whatever he might have accomplished he would always have remained a singularly interesting character.

The doer of some striking deed soars for a space to the zenith of popular favor, and his fall is often the greater when ousted by the next darling of the public. But Nordenskiöld, from the day he entered Sweden, banished from his native Finland by the Russian government for an over-pointed after-dinner speech which he declined to withdraw, to the day when he died full of honors from all nations, was ever a hero of the Swedes, the one man whose features and fame were known in every village of the land. Fifteen years after the return of the *Vega* I crossed Sweden in his company. The lake steamer on which we set foot was speedily dressed with flags from stem to stern; as we paced the railway platform, folk turned to point him out to their children; an apothecary into whose shop we stepped drew us into his parlor to point with pride to a medallion of the hero hung in the place of honor; even a drive with him through the streets of Stockholm, where his presence was familiar, was not without embarrassment. Those who knew Nordenskiöld can understand this easily. He impressed the popular imagination like some grand mysterious figure of the Middle Ages. Rarely did man so combine the profound research of the student with the decisive energy of the geographical explorer, the remote and even fantastic speculations of the philosopher with the business-like ability of a prudent organizer, the absent-minded reverie and complete absorption of the recluse with the wide sympathies and practical readiness of a liberal politician. These broad outlines of his character were obvious to all, and manifest too in his outer person. The deep-set far-away eyes and the furrowed forehead above the shaggy eyebrows proclaimed him a seer of visions and a diver into nature's secrets, while the hard lines of the mouth and prominent underlip told of an obstinate patience joined to a fiery Viking temper; the bowed shoulders of the bookworm, voracious of fusty manuscripts in the dark recesses of a library, were belied by the firm elastic tread of the sailor and mountaineer.

The things he did and the things he said were striking in themselves, but they were the outcome of his yet more striking personality. People talked of Nordenskiöld's luck. He had the luck of all who lay the foundations of their plans deep, who make every preparation suggested by learning and experience, who know how to wait for the fitting moment, and who have the boldness to go ahead unswervingly when the opening appears. It was the exhaustive detail of his plans for the northeast passage that awoke the admiration, and gained the support, of King and people; it was by forethought, and not only by daring, that he brought the *Vega* and her consorts

from ocean to ocean, unscathed and without the loss of a single man. It was by readiness and prompt decision that he steered the *Sofia* to what, but for the Englishman, Parry, had then been the farthest north, and that on another voyage he burst the icy barrier of southeastern Greenland, which had defied assault for three hundred years.

These expeditions to Greenland were inspired largely by his desire to see the remains of the ancient Österby, the settlement of the Norsemen, an inspiration as much sentimental as scientific. On the other hand, his early voyages to Siberian waters, though not unfruitful of scientific results, were as grossly commercial as those of his fellow-pioneers, Captains Carlsen and Wiggins. But mere trade would not have taken Nordenskiöld to the mouth of the Yennissei, and we believe that in the night-watches there ever loomed before him the shadow of Tchelyuskin, the cape that he would be the first to double.

As keeper of the minerals in the State Museum at Stockholm, Nordenskiöld had to deal with objects that may be thought petty in comparison with his famous exploits. But the professor was a poet, always seeing the greater in the less, and thus it was that the dust falling on Arctic snows through the long night was for him a message from other worlds than ours, a suggestion of some primeval harbinger that brought to a cooling planet the germ of all life. So, too, a prolonged study of cracks in granite, to which his attention was first directed on Spitzbergen, led him, by a process of reasoning too complicated for repetition here, to the belief that they must penetrate to a depth of thirty to forty meters below sea-level and no further, since there they would meet with a system of horizontal cracks. Water would sink through the first set of cracks to that depth, and there would form a constant source of supply. The theory was proved correct by the diamond drill, and from it wider consequences of geological import inevitably result. But the practical benefits, especially in the large granitic areas of Sweden and Finland, are no less, and at Nordenskiöld's instigation large numbers of bore-holes have now been sunk, lighthouses on seagirt rocks furnished with a never-failing spring, and factories supplied with pure water previously obtainable only at great expense. 'Nordenskiöld's wells' will soon be household words, and they who understand neither mathematics nor geology know at least that like the prophet of old he has brought forth water from the stony rock.

But it is not my purpose to discuss the scientific labors of Nordenskiöld, so much as to illustrate his personality. Stern and reserved in appearance, he was often so in reality, but this arose rather from his abstraction in deep problems than from any aloofness of nature. He was not high-minded, however proud his looks, and could unbend without a trace of condescension. He was not a good speaker, but he was an inveterate one, and, as we have seen, his freedom of youthful speech cost him his post and his native land. On the triumphal homeward voyage of the *Vega*, there were banquets at every port of call, and Nordenskiöld, who of course spoke, employed always the language of the country. It was his custom. Even in Japan, after a few weeks' stay, he replied to the toast of his health in Japanese. The speech was not reported.

Wherever he went he collected objects of interest, and the collection he made in Japan was characteristic. He bought up all the books and manuscripts he could lay hands on, and so it is that there now exists in the Royal Library at Stockholm perhaps the finest collection of Japanese literature in Europe. The catalogue by Professor Rosny, of Paris, is well known to Orientalists.

Nordenskiöld was also a voluminous

writer. He was perhaps too fertile in ideas to have the lucidity that makes the good writer. Many of his sentences struggle through ponderous verbiage only to die in the folds of an ambiguous anacoluthon. But a picturesque phrase sparkles out here and there, as when in reference to some modern geological theories, he says, 'still the student of science is groping here, like a child after the silvery disc of the moon.' A sentence that an unkind critic might apply to some of the philosopher's own speculations.

Further illustrations of Nordenskiöld's many-sided character might be drawn from aspects of his life here scarcely referred to. Enough has been said to render intelligible the hero-worship of the Swedish people. Is the world too old for a Nordenskiöld myth to be possible? I doubt one is even now in the making among the remote homesteads in Scandinavian forests.

F. A. B.

AN ITALIAN IN AMERICA.

PROFESSOR ANGELO MOSSO, the genial physiologist of the University of Turin, has written a pleasant and plausible little book about America, which has been praised in various places. He duly pats us on the back and tells of our strong and weak points. 'Hurry up' is our national motto, and we are a rampant plutocracy. We make inventions, but democracy is hostile to pure science. Our neurasthenic tendencies are duly described as also our 'spoils system.' Religious sentiment is growing, and we are turning towards the Roman Catholic Church. Our universities are not progressing, owing to sectarian control. All this will be found in the book; but perhaps it is scarcely fair to quote it, as there is much there besides. Now how does Professor Mosso know us so well? He spent a month or two here on the occasion of the decennial of Clark University, and though he can not understand an English sentence, he saw us from the windows of the railway train. The writer of the present note had the pleasure of meeting Professor Mosso when he was here. He threw his arms about him in a warm embrace. Then he produced a slip from his pocket and proved by documentary evidence that there were two Americans whom he should kiss on both cheeks and about a dozen whom he should cordially embrace. Professor Mosso said later that he wished to write a book about American universities. It was explained to him that midsummer was an unfortunate time, the only university carrying on its sessions being Chicago. He asked: "Where is Chicago? Is there a university there?" The position of Chicago on Lake Michigan was described. He then said: "Can I see the University of Chicago to-day and be back in Worcester this evening?" These little anecdotes are told in the most kindly spirit by one who really admires Professor Mosso. But I must protest against his argument that there is no fundamental difference between an American and an Italian.

K.

SCIENTIFIC LITERATURE.

PHYSICS.

'THE PROCEEDINGS of the Paris Congress of 1900 on Methods of Testing Materials' have just appeared in three large folio volumes. The first article by M. Ricour has for its title 'The Molecular Constitution of Matter,' but is largely devoted to the discussion of the laws of attraction and to the properties of the ether of space. This ether he imagines to be a sphere whose radius, though great, may perhaps be ultimately found. The distance of our sun from the center of this sphere of ether he finds to be such that light would require 140,000 years to traverse it. The density of the ether he finds to be such that a mass equal in size to our earth would be equal to about one kilogram. While much of the work rests upon hypotheses, the article of Ricour is interesting as showing how the engineer as well as the physicist finally comes to the ether as the ultimate source of all energy. If the ether is really a limited sphere, as he supposes, the surface of that sphere forms an absolute limit to our knowledge; for should other spheres of ether exist no waves can pass across the empty spaces that separate them from that sphere which contains our universe.

MOSQUITOES AND MALARIA.

DR. LELAND O. HOWARD, the entomologist to the United States Department of Agriculture, has just given us a little book on 'Mosquitoes' (McClure, Phillips & Co.) that is peculiarly well timed and important. Dr. Howard has studied his subject for many years; primarily, in the past, to devise methods for the local control of an annoying pest; but recently, since the relation of some of the genera to the spread of malarial and other febrile diseases has been established, to ascertain their peculiarities of habit and development.

Public interest in the newspaper and magazine accounts has been so marked that a book like this which gives in concise form and with scientific accuracy just what is known of the relation between disease and insects must be especially useful to correct the misinformation gaining currency among the general public. Dr. Howard gives us in detail the life history of our commonest species; both *Culex*, which is an annoyance merely, and *Anopheles*, which is the intermediate host for the organism producing malarial diseases in man. The breeding places of each are discussed and the measures which may be adopted to do away with them. A very complete account is given of the experiments which link the *Stegomyia fasciata* with yellow fever, and a brief statement shows the relation between *Culex ciliaris* and Filariasis. A chapter on classification shows fairly well what is known of our American species and gives some indication of what yet remains to be learned.

THE PROGRESS OF SCIENCE.

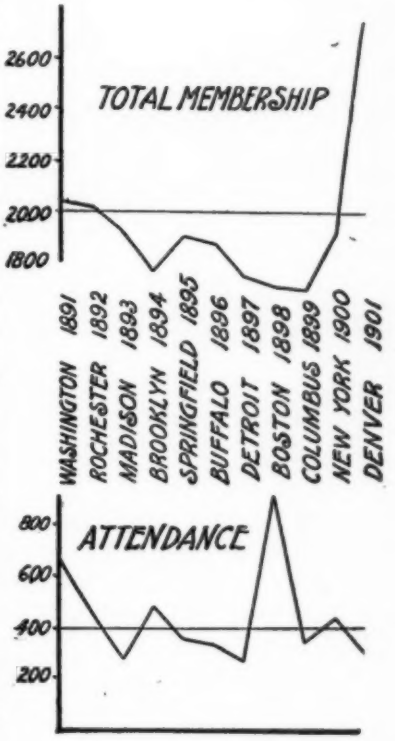
THE AMERICAN ASSOCIATION.

THE meeting of the American Association for the Advancement of Science held at Denver during the last week of August was of more than usual significance. For the first time in its history the Association met west of the banks of the Mississippi. California was ceded to the United States in the same year in which the Association held its first meeting, and the great western half of the country and the Association representing science in America have developed together. It was Frémont, then a scientific man engaged in scientific surveys, who saved California for the Union. The western States—dependent on railways, mines and modern agriculture—are the children of science. Having attained through science their remarkable material development, they are now prepared to unite with the older culture of the east in efforts for the advancement of science. Extending from the Mississippi river to the Pacific coast we have the first civilization based definitely on science, and we may expect to see in this region the world's chief centers for the diffusion and advancement of science. The first meeting of the American Association in the west is merely an announcement of what has been accomplished already, yet it represents an epoch in the history of science and of civilization.

THE meeting at Denver was itself full of interest. Though not quite so large as meetings on the Atlantic seaboard, it was larger than the recent meetings at Madison and Detroit, and nearly as large as the meetings at Springfield, Buffalo and Columbus. Further, the 306 members in attendance were mostly scientific men, as is shown by the fact that two hundred and twenty papers were presented. The people of Denver did everything possible to ensure the social success of the meeting, and the scenery and resources of the State of Colorado were of the greatest possible interest to all visitors. The address of the president, published above, was worthy of the occasion, and many interesting papers were read before the different sections. In several respects the business transacted was of importance in the history of American science. The committee on the journal, 'Science,' made its first report on the arrangement made at the New York meeting last year, in accordance with which this weekly journal is sent free of charge to all members of the Association. It appears that the fees of new members were sufficient to defray the cost of sending 'Science' to all members of the Association, and that the plan has proved acceptable on all sides. Another important step was the perfecting of the affiliation of the special societies with the Association. Hitherto the national societies devoted to the special sciences have met informally with the Association; hereafter they will be an integral part of it, being represented on the council. The council will thus become the body chiefly responsible for the organization of science in America. The Association planned for a winter meeting to be held at Washington a year from next January. Attention has already been called here to the movement now progressing for the establishment of a convocation week for the meetings of scientific and learned societies. It is now assured by the action of our leading universities and of the American

Association that this week—that in which the first day of the new year falls—will hereafter be devoted to the purpose designated. The meeting of the American Association next year will be at Pittsburg at the beginning of July, and will be presided over by the great astronomer, Professor Asaph Hall. It will undoubtedly be large and important; while the meeting at Washington will probably be the greatest scientific congress ever held in America.

THERE was published in this Journal for July last an article on the American Association for the Advancement of Science calling attention to the great importance and responsibility of this institution for the development of science. Trusts and trade unions are an integral part of our present civilization, and it is our duty not to protest against them, but to direct them for the common good. Those interests that are most important for civilization should have the strongest organization, and it is gratifying to find that under the auspices of the American Association a union is being effected that will adequately represent the scientific interests of the country. There was a period of disintegration when the development of the special sciences required the formation of special societies, but we are apparently now in the midst of a movement toward such a concentration of authority as will not interfere with local autonomy. Herewith is given a curve showing the total membership of the American Association and the attendance at the meetings since that in Washington in 1891, when the membership reached its maximum. It will be noticed that there was a tendency for the membership gradually to decrease, broken only by an accession at the large Brooklyn meeting of 1894. The curve, however, rises in a remarkable way for the New York and Denver meetings. This has doubtless been largely due to the arrangement with 'Science,' mentioned above, and to the efficiency of the present permanent secretary, Dr. L. O. Howard, in bringing the desirability of membership in the Association before the scientific men of the country. These, however, are only incidents that have hastened the development of a movement demanded by modern conditions.



MORTALITY STATISTICS.

A BULLETIN issued from the census bureau at the end of August gives vital statistics of more than usual interest. The death rates of 1900 and 1890 are compared both as regards different regions and as regards different causes of death. It appears that careful registration of deaths is undertaken in ten States and in a large number of cities, including about twenty-nine million of the inhabitants of the country.

The statistics disclose the very gratifying fact that in ten years the general death rate has decreased from 19.6 per thousand to 17.8. This remarkable decrease is in the cities, where the rate has fallen from 21 in 1890 to 18.6 last year. The rate in the country has been about stationary, having been 15.3 in 1890 and 15.4 in 1900. This extraordinary decrease in the death rate of cities has been due chiefly to improved hygienic conditions. In the country a corresponding gain has not occurred. We may perhaps look for it in the course of the next ten years, though there is of course less room for improvement. New York City has one of the best records of progress, its death rate having decreased in ten years from 25.3 to 20.4, making the city in spite of its crowded tenement districts as healthful as Boston and decidedly more healthful than Philadelphia, in which city the death rate has remained practically stationary. But there is room for further progress in our eastern cities. Chicago has a death rate of only 16.2, and nearly all the cities of the northern and central States have a low death rate, Minneapolis and St. Paul, for example, having the incredibly low rates of 10.8 and 9.7, respectively. The most unfavorable conditions are in the south, the death rate of New Orleans, for example, being 28.9, an increase since 1890; and that of Charleston, 37.5, about the same as ten years ago. Almost as interesting as the decrease in the death rate is the decrease due to certain special diseases. The following table deserves to be quoted in full. It shows the death rate due to certain diseases per hundred thousand of population in the registration area in 1900 and 1890 together with the increase or decrease in the rate.

Causes.	Death Rate.		Increase.	Decrease.
	1900.	1890.		
Consumption	190.5	245.4	.....	54.9
Debility, atrophy	45.5	88.6	.....	43.1
Diphtheria	35.4	70.1	.....	34.7
Cholera infantum	47.8	79.7	.....	31.9
Bronchitis	48.3	74.4	.....	26.1
Convulsions	33.1	56.3	.....	23.2
Diarrhœal diseases	85.1	104.1	.....	19.0
Croup	9.8	27.6	.....	17.8
Typhoid fever	33.8	46.3	.....	12.5
Dis. of the brain	18.6	30.9	.....	12.3
Malarial fever	8.8	19.2	.....	10.4
Unknown cause	16.8	24.6	.....	7.8
Inflammation of the brain and meningitis	41.8	49.1	.....	7.3
Hydrocephalus	11.0	15.4	.....	4.4
Dropsy	6.9	10.3	.....	3.4
Whooping cough	12.7	15.8	.....	3.1
Paralysis	32.8	35.5	.....	2.7
Scarlet fever	11.5	13.6	.....	2.1
Septicæmia	10.0	7.7	2.3	.....
Diabetes	9.4	7.5	3.9	.....
Pneumonia	191.9	186.9	5.0	.....
Premature birth	33.7	25.2	8.5	.....
Old Age	54.0	44.9	9.1	.....
Cancer	60.0	47.9	12.1	.....
Heart disease	134.0	121.8	12.2	.....
Apoplexy	66.6	49.0	17.6	.....
Influenza	23.9	6.2	17.7	.....
Dis. of the kidney	83.7	59.7	24.0	.....

This table shows that consumption is no longer the most fatal of diseases, pneumonia having taken its place. Deaths from consumption have decreased over 20 per cent., while a greater relative decrease is recorded in the case of diphtheria and other diseases. The diseases that show an increase are chiefly those incident to advanced age, death from old age itself showing an increase of 20 per cent.

ARCTIC EXPLORATION.

THE steamship *Erik* has returned, bringing welcome news of Lieutenant Peary. It appears that he has succeeded in rounding the limit of the Greenland Archipelago, probably the most northern land, and has reached the highest altitude yet attained in the western hemisphere (83° 50′). Mr. Robert Stein and Mr. Samuel Warmbath were picked up by the *Windward*, but there is no news regarding Captain Sverdrup. During the present autumn Lieutenant Peary expects to make explorations and in the spring of next year again to make the attempt to pro-

ceed as far north as possible. In the meanwhile, Mr. Baldwin is making a similar attempt from another direction, and there are a number of other expeditions in the far north, Baron Toll, who started from Russia in May, 1900, was recently in the Strait of Tarmour, while from the same country, Admiral Markaroff is testing his ice-breaking steamship. From Norway, Captain Sverdrup on the *Fram* has for three years been making explorations about Greenland and west of Ellesmere land. From Germany, Captain Banandahl was, when last heard from, advancing north from Spitzbergen. None of the expeditions in the north are of the same scientific importance as the national antarctic expeditions of Great Britain and Germany, but it seems certain that the next year will add greatly to our knowledge of the unknown regions of the north as well as of the south.

SCIENTIFIC ITEMS.

PROFESSOR WILLIAM THEODORE RICHARDS, of Harvard University, has declined a call to a newly-established research professorship of chemistry in the University of Göttingen. It is a special compliment to the United States that Germany should seek here a professor for such a chair, especially when we remember the large number of chemists that are trained at the German universities.—On the application of the Government of Victoria, Australia, for a director of agriculture, officers of the U. S. Department of Agriculture have recommended Professor B. T. Galloway, chief of the Bureau of Plant Industry, and Professor Willett M. Hays, agriculturist of the Minnesota Experiment Station.

THE Reale Accademia dei Lincei of Rome has elected eight foreign members, including from the United States Edward C. Pickering, director of the Harvard College Observatory; Samuel P. Langley, Secretary of the Smithsonian Institution, and Chas. D. Walcott, director of the U. S. Geological Survey.—The Veitch silver medal has been awarded to Mr. Thomas Meehan, of Philadelphia, 'for distinguished services in botany and horticulture.' Mr. Meehan is the third American on whom this medal has been conferred, the others being Professor Charles S. Sargent, of the Arnold Arboretum, and Professor Liberty H. Bailey, of Cornell University.

PROFESSOR ED. SUESS, the eminent geologist, gave on July 13 a formal lecture to his present and former students on the occasion of his retirement from the chair of geology. He has reached his seventieth year and his forty-fourth year as a university teacher.—Dr. Ernst Mach, professor of philosophy in the University of Vienna, has been compelled by ill health to retire from the active duties of his professorship.—Professor E. Haeckel, of Jena, has made public the announcement that owing to the state of his health, his advanced age and pressure of work, he will not in future make any public addresses or attend any scientific congresses.

A ROYAL commission has been appointed in Great Britain to study the relation of bovine and human tuberculosis, consisting of Sir Michael Foster, Dr. Sims Woodhead, Dr. Harris Cox Martin, Professor J. McFadyean and Professor R. W. Boyce.

THE British Association for the Advancement of Science held its meeting at Glasgow from September 11–18 under the presidency of Professor A. W. Rücker, the eminent physicist. The Congress of German Men of Science and Physicians is being held at Hamburg from September 22–28, under the presidency of Professor R. Hertwig, the well-known zoologist.

Science also mourns the death of the President of the Nation. We have lost a good man, representing the sterling qualities of the people. We honor a man who became great when brought face to face with circumstance. McKinley stands with Washington and with Lincoln. He who founded the Nation, he who preserved it, and he who gave it leadership, rank apart from those who lacked opportunity. The diseased brain of an assassin can not alter the course of history. When our leader falls, another is ready to take his place. But we do not forget him over whose body we advance. He is not ill-starred in his death who is honored and loved and mourned by a Nation.

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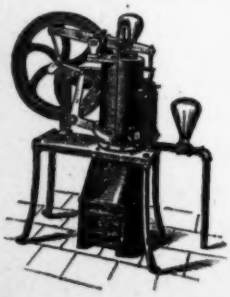

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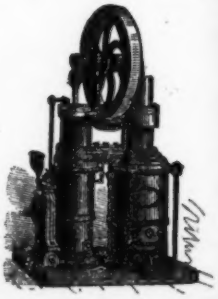

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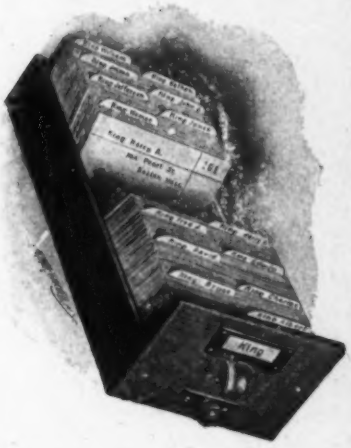

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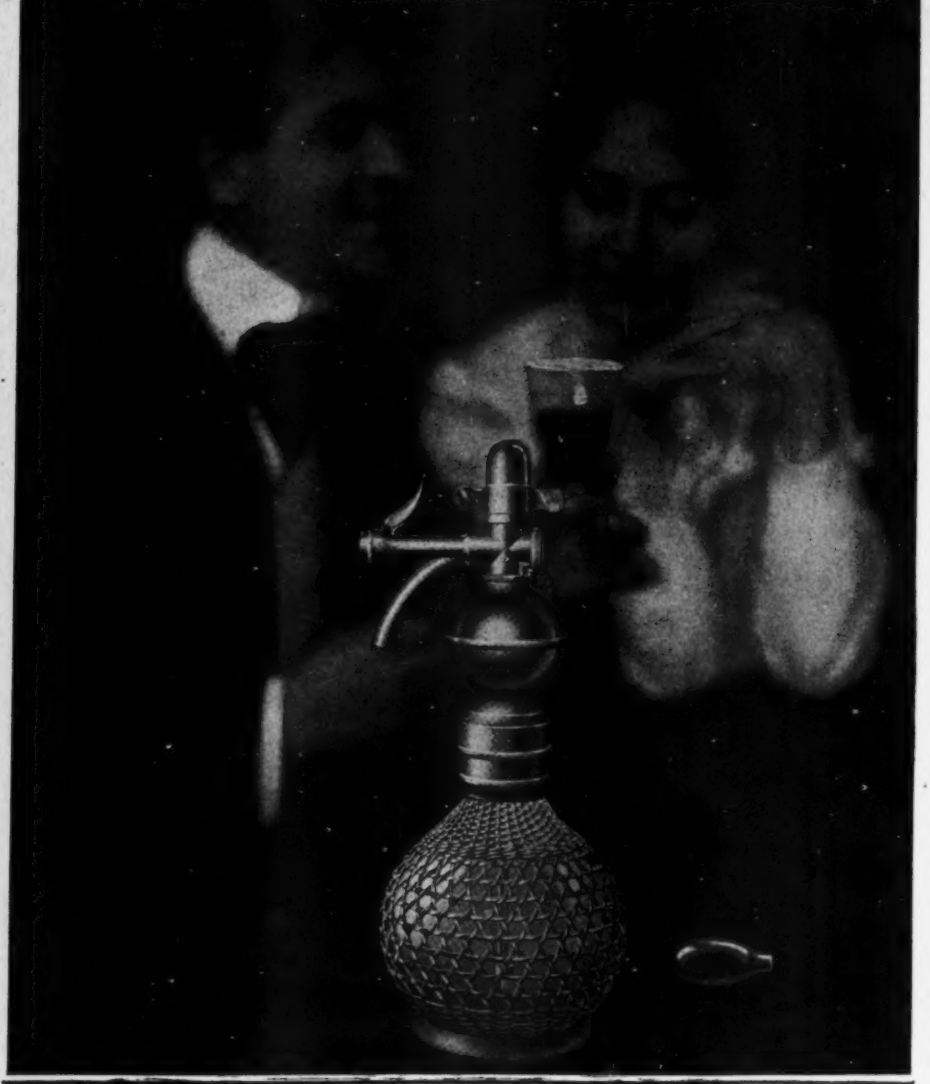

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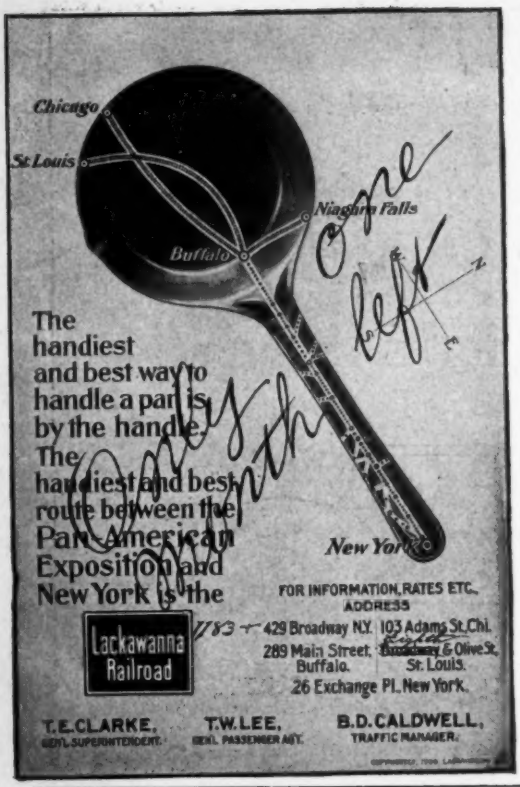
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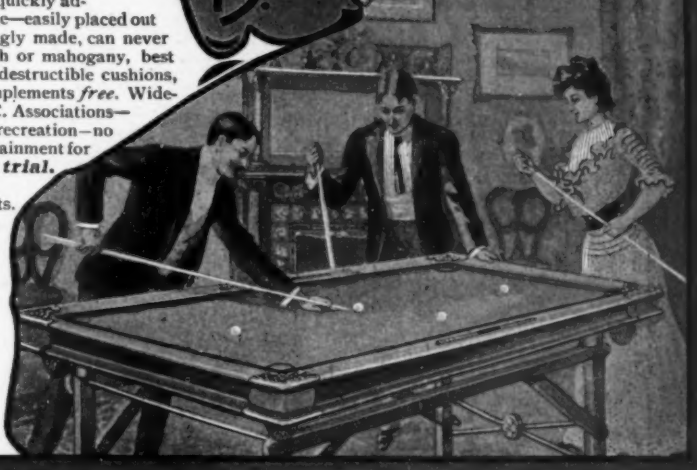

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